

RED LIGHT LOCAL FAUNA (BLANCAN) OF THE LOVE FORMATION, SOUTHEASTERN HUDSPETH COUNTY, TEXAS



By
William A. Akersten

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Texas Memorial Museum

The University of Texas at Austin

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RED LIGHT LOCAL FAUNA (BLANCAN) OF THE
LOVE FORMATION, SOUTHEASTERN HUDSPETH COUNTY, TEXAS

BY

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ABSTRACT

Two new formations in the Red Light Bolson have yielded vertebrate fossils. The Red Light local fauna consists of thirty taxa of mammals and numerous lower vertebrates from fluvial deposits. The much smaller Aguila local fauna is from older playa deposits.

The stratigraphic and faunal successions indicate a climatic change from arid playa conditions to moist fluvial conditions. This change is probably a result of the onset of pluvial conditions related to glaciation at higher latitudes. At the time that the youngest part of the Red Light local fauna lived, the bolson was occupied by a permanent, flowing drainage and three major terrestrial environments probably existed in the area. Brush or succulent vegetation grew along the drainage, a savannah with scattered trees existed between the drainage and the mountains, and the mountains were largely covered with brush.

The playa and fluvial deposits are correlated with the Fort Hancock and Camp Rice Formations, respectively, in the Hueco Bolson. The Red Light local fauna correlates with the Hudspeth local fauna from the Hueco Bolson. Faunal evidence indicates that it lived during the Pleistocene portion of the Blancan and, from stratigraphic evidence, this is narrowed to the Nebraskan.

INTRODUCTION

Pleistocene and upper Pliocene vertebrates from the bolson deposits of the southwestern United States and adjacent Mexico are not well known. In Texas only the material from the Hueco Bolson has been described (Strain, 1966). The Mesilla Bolson in New Mexico has yielded some Pleistocene material, mostly undescribed. Gidley (1922 and 1926), Gazin (1942), and many others have described vertebrates from the Benson and Curtis Ranch faunas from bolson deposits along the San Pedro River valley in Arizona. A few small collections have been described from other bolsons.

Underwood (1963), mapping in the area of the Eagle and Indio Mountains in southeastern Hudspeth County, Texas, discovered Pleistocene vertebrate remains in the sediments of the Red Light Bolson. In 1960, J. A. Wilson, J. Paulson, W. S. Strain, and J. R. Underwood made preliminary collections. I collected additional material during 1964 and 1965. The faunas represented by these collections are herein designated the Red Light and

Aguila local faunas.

Location.—The Red Light Bolson (Underwood, 1963) is in a graben or half-graben trending northwest-southeast in southeastern Hudspeth County, Texas, between the Devil Ridge-Eagle Mountains-Indio Mountains chain to the northeast and the Quitman Mountains to the southwest (fig. 1). The part of the bolson under consideration in this paper is bounded by the Rio Grande to the southwest and south, the front of the Indio Mountains to the northeast, and about latitude $31^{\circ} 47'$ N. to the north (fig. 2). This area is included in Underwood's map (1963). It is on parts of the Bramblett and Guerra ranches.

Acknowledgments.—This problem was supervised by Dr. E. L. Lundelius of the University of Texas. His suggestions, advice, and patience are deeply appreciated. I am indebted to J. A. Wilson and Prof. R. K. DeFord of the same institution, and members of the committee, for their advice and constructive criticism.

Dr. E. C. Jonas of the University of Texas ran the X-ray clay analysis. J. G. Lundberg of the University of Michigan identified the fish. P. Brodkorb of the University of Florida provided a preliminary list of the birds. M. F. Skinner of the Frick Laboratory, American Museum of Natural History, generously provided advice on the taxonomy of equids. J. G. Mead and K. Kutasi prepared the photographic illustrations. Mrs. M. S. Stevens, MSS, drew all but one of the faunal illustrations and contributed much advice on preparation and osteology. E. J. Deemer, EJD, drew one illustration. I am grateful for their assistance. Discussions with those just named, as well as with Dr. C. Hubbs, Dr. D. Reaser, Dr. P. E. Twiss, and Dr. J. B. Stevens, proved enlightening.

The following people loaned specimens, provided casts, or made collections available during personal visits: Dr. T. Downs and Dr. J. R. Macdonald of the Los Angeles County Museum, Dr. D. E. Savage of the University of California at Berkeley, Dr. D. S. Webb of the Florida State Museum, and Dr. C. W. Hibbard of the University of Michigan. I should also like to acknowledge with thanks Dr. Hibbard's advice and critical reading of the manuscript.

Permission to work on their land was graciously given by Leo and Robert Guerra and Mr. and Mrs. John D. Bramblett. The hospitality of the Brambletts made life in the field more pleasant.

Financial support was provided by the Department of Geological Sciences, University of Texas at Austin and an NDEA Title IV Fellowship. A Grant-in-Aid of Research from the Society of the Sigma

Xi made possible the preparation and illustration of this report.

Techniques.—I collected larger vertebrate bones by walking and searching the outcrops. Only one of the more than 700 specimens collected included any associated material. No locality is rich enough in the remains of large vertebrates to warrant quarrying. The micro-vertebrates were collected by surface picking and, at locality TMM 40857, by dry screening and washing.

The horse teeth were prepared for sectioning in the following manner. They were vacuum impregnated with a thin solution of polyvinylacetate and alcohol, coated with a thin layer of petroleum jelly, imbedded in a dental casting plaster, and vacuum impregnated a second time. The petroleum jelly allowed the plaster to be easily removed after sectioning. Other preparatory techniques were standard.

Large measurements were made with wooden calipers calibrated in millimeters. Small measurements were made with steel calipers calibrated in 0.1 mm. The measurements recorded in 0.01 mm were measured with a Gaertner measuring microscope which measured in increments of 0.001 mm.

Abbreviations.—For measurements, mm and cm are used for millimeters and centimeters. Abbreviations referring to paleontological collections are:

AM	American Museum
TMM	Texas Memorial Museum
CIT	California Institute of Technology (now at the Los Angeles County Museum)
MSS	Margaret Skeels Stevens (private Recent collection)
UCMP	University of California Museum of Paleontology
USNM	United States National Museum

Previous work.—The only publication which has much bearing on the deposits of the Red Light Bolson is that of Underwood (1963). Albritton and Smith (1965) worked farther to the north where the older deposits of the Red Light Bolson do not crop out. Underwood (1963) also mapped the deposits in the western part of the Green River and associated bolsons. Twiss (1959) mapped the deposits in the eastern part of these bolsons. DeFord and Bridges (1959) described the Tarantula Gravel from the Green River Bolson. Much work, mostly unpublished University of Texas theses, has been done in the bolson deposits farther down the Rio Grande. Dickerson (1966) is the only one of these which treated the bolson fill at great length.

To the east of Underwood's area, Jones (in manuscript) mapped the western portion of the Red Light Bolson. Strain (1966) mapped an area of the Hueco Bolson and summarized previous work on that bolson. Bell (1963) mapped an area of the Hueco Bolson to the east of the area mapped by

Strain.

In Mexico, Reaser (in manuscript) has mapped the fill in the southern part of the Red Light Bolson. Haenggi (1966) mapped in the El Cuervo Bolson and the western part of the Presidio Bolson but only very young fill is exposed in the El Cuervo Bolson. Figure 1 gives the locations of these mapped areas.

Geologic setting.—The following data are from Underwood (1963) and personal observation unless otherwise noted.

East of the outcrop area of bolson fill under consideration in this paper are the Indio Mountains. Lower Cretaceous conglomerate, sandstone, shale, and limestone and Tertiary volcanic rock, mostly trachyte and tuff, crop out in these mountains. The only outcrops contributing to the modern alluvium in the Red Light Bolson in the area studied are the siliceous conglomerate, sandstone, and shale of the Lower Cretaceous Yucca Formation. The Yucca makes up most of the western Indio Mountains and is the only formation adjacent to the bolson fill in the area studied. It dips to the east so that the lower part of the section crops out closest to the bolson fill. The lower Yucca is mostly conglomerate; it becomes progressively finer grained higher in the section, farther from the bolson.

The outcrops at Eagle Mountain, to the north, are mostly Tertiary syenite, trachyte porphyry, and rhyolite. Northwest of the Eagle Mountains are outcrops of Lower Cretaceous conglomerate, sandstone, and limestone including those of Devil Ridge. The outcrops along the east side of the Quitman Mountains are of the same general nature as in the Eagle-Indio Mountains except that the Yucca is not exposed (D. Reaser, oral communication, 1967).

STRATIGRAPHY

New names, the Bramblett Formation and the Love Formation, are herein proposed for two lithologic units within the Red Light Bolson. The names proposed by Strain (1966) for lithologic units of similar ages and similar gross appearances in a nearby area of the Hueco Bolson should not be applied to the units in the Red Light Bolson for the following reasons: The two bolsons represent different basins of deposition with different source areas for the sediments. Although the compositions of corresponding formations in the two bolsons are grossly similar, they differ in detail. The differences are a reflection of the source areas and slight differences in the environments of deposition. If the formational names used in the Hueco Bolson were applied to the lithologic units in the Red Light Bolson, it would be done because of similar geologic history and time equivalence. These are not valid criteria for the recognition of rock-stratigraphic units (American Commission on Stratigraphic No-

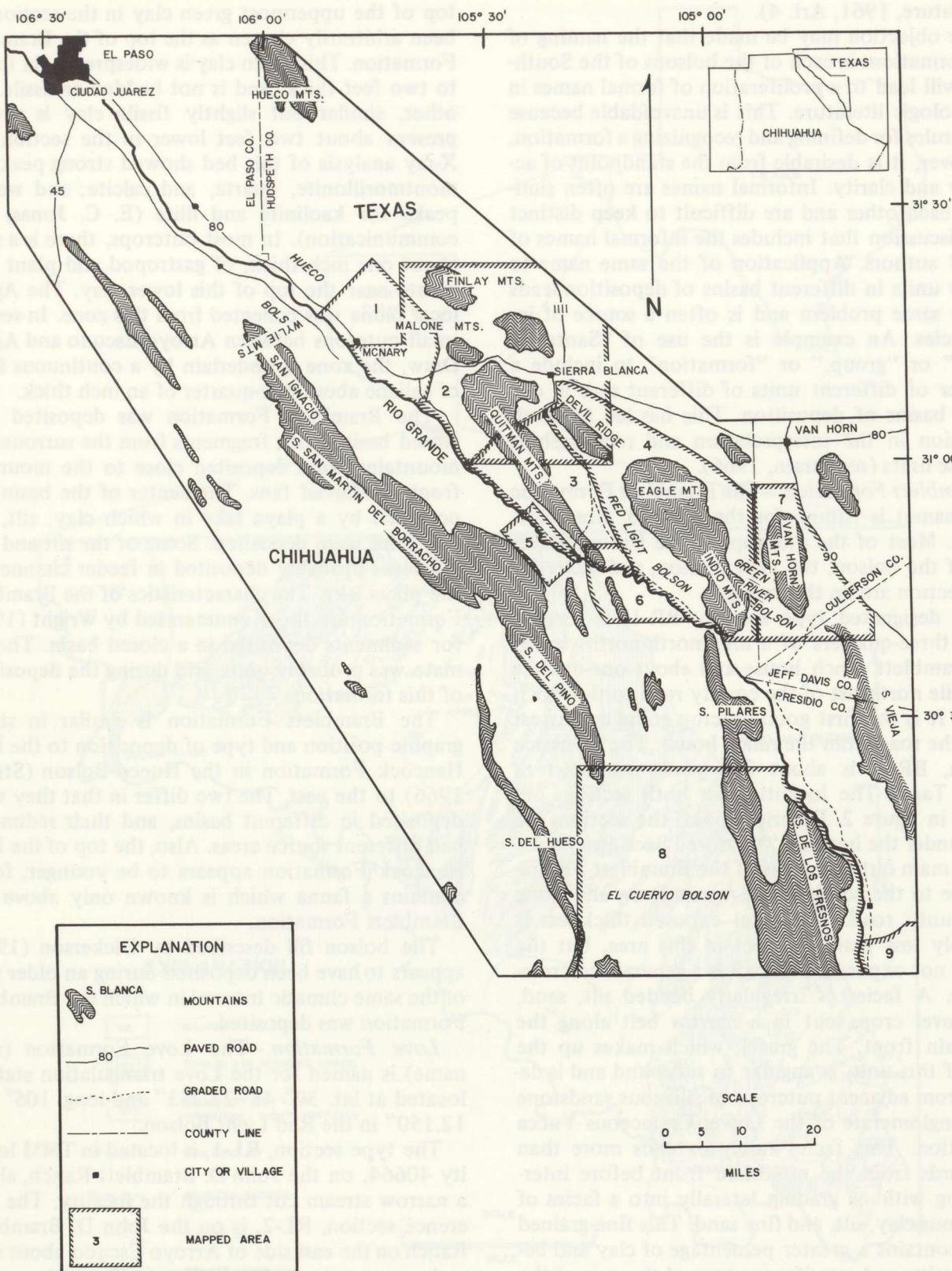


Fig. 1.—Physiography and mapped areas near the Red Light Bolson (after Bell, 1963). Index to mapped areas: 1, Strain (1966); 2, Albritton and Smith (1965); 3, Jones (in manuscript); 4, Underwood (1963); 5, Bell (1963); 6, Reaser (in manuscript); 7, Twiss (1959); 8, Haenggi (1966); 9, Dickerson (1966).

menclature, 1961, Art. 4).

The objection may be made that the naming of new formations in each of the bolsons of the Southwest will lead to a proliferation of formal names in the geologic literature. This is unavoidable because of the rules for defining and recognizing a formation. Moreover, it is desirable from the standpoint of accuracy and clarity. Informal names are often similar to each other and are difficult to keep distinct in a discussion that includes the informal names of several authors. Application of the same name to similar units in different basins of deposition leads to the same problem and is often a source of inaccuracies. An example is the use of "Santa Fe marls," or "group," or "formation" to include a number of different units of different ages in different basins of deposition. This has led to much confusion in the interpretation and relationships of these units (see Strain, 1966).

Bramblett Formation.—The Bramblett Formation (new name) is named for the John D. Bramblett Ranch. Most of the outcrops in the United States part of the bolson, the type section, and the reference section are on this ranch.

The designated type section, BR-1, is located about three-quarters of a mile north-northwest of the Bramblett ranch house and about one-quarter of a mile northeast of the county road to the ranch house. It is the first good outcrop going northwest along the road from the ranch house. The reference section, BR-2, is about 200 yards northeast of Dome Tank. The localities for both sections are shown in figure 2. Descriptions of the sections are given under the heading "Measured Sections."

The main outcrop areas of the Bramblett Formation are to the southeast of Aguila Draw and along the county road. The total exposed thickness is probably less than 250 feet in this area, but the base is not exposed. Figure 3 is a generalized cross-section. A facies of irregularly bedded silt, sand, and gravel crops out in a narrow belt along the mountain front. The gravel, which makes up the bulk of this unit, is angular to subround and is derived from adjacent outcrops of siliceous sandstone and conglomerate of the Lower Cretaceous Yucca Formation. This facies rarely extends more than 200 yards from the mountain front before interfingering with or grading laterally into a facies of calcareous clay, silt, and fine sand. This fine-grained facies contains a greater percentage of clay and becomes salty and gypsiferous toward the axis of the bolson. The clay is yellow, green, and reddish brown. The silt and fine sand are buff to light brown. Most beds are lenticular and of small lateral extent. Correlation of scattered outcrops is usually impossible.

Toward the top of the formation the fine-grained facies contains more sand and silt and grades into overlying fluvial deposits. No significant break in sedimentation has been found although most silt and sand beds have channeled lower contacts. The

top of the uppermost green clay in the section has been arbitrarily chosen as the top of the Bramblett Formation. This green clay is widespread, six inches to two feet thick, and is not bedded or fissile. Another, similar but slightly fissile clay is usually present about two feet lower in the section. An X-ray analysis of this bed showed strong peaks for montmorillonite, quartz, and calcite; and weaker peaks for kaolinite and illite (E. C. Jonas, oral communication). In most outcrops, there is a zone about one inch thick, of gastropod and plant fragments near the top of this lower clay. The Aguila local fauna was collected from this zone. In several small outcrops between Arroyo Escudo and Aguila Draw, the zone is underlain by a continuous layer of caliche about one-quarter of an inch thick.

The Bramblett Formation was deposited in a closed basin. Rock fragments from the surrounding mountains were deposited close to the mountain front as alluvial fans. The center of the basin was occupied by a playa lake in which clay, silt, and fine sand were deposited. Some of the silt and fine sand was probably deposited in feeder channels of the playa lake. The characteristics of the Bramblett Formation are those enumerated by Wright (1946) for sediments deposited in a closed basin. The climate was probably quite arid during the deposition of this formation.

The Bramblett Formation is similar in stratigraphic position and type of deposition to the Fort Hancock Formation in the Hueco Bolson (Strain, 1966) to the east. The two differ in that they were deposited in different basins, and their sediments had different source areas. Also, the top of the Fort Hancock Formation appears to be younger, for it contains a fauna which is known only above the Bramblett Formation.

The bolson fill described by Dickerson (1966) appears to have been deposited during an older part of the same climatic interval in which the Bramblett Formation was deposited.

Love Formation.—The Love Formation (new name) is named for the Love triangulation station located at lat. $30^{\circ} 48' 27.253''$ and long. $105^{\circ} 12' 12.150''$ in the Red Light Bolson.

The type section, RL-1, is located in TMM locality 40664, on the John D. Bramblett Ranch, along a narrow stream cut through the locality. The reference section, RL-2, is on the John D. Bramblett Ranch on the east side of Arroyo Escudo about two and one-quarter miles upstream from the point where the arroyo crosses the road. The localities of both sections are shown in figure 2 and their descriptions are given under the heading "Measured Sections."

The main outcrop area is to the northwest of Aguila Draw. Probably less than 200 feet of section are exposed in this area. The base is arbitrarily defined as the top of the highest green clay. Figure 3 is a generalized cross-section. Two major facies

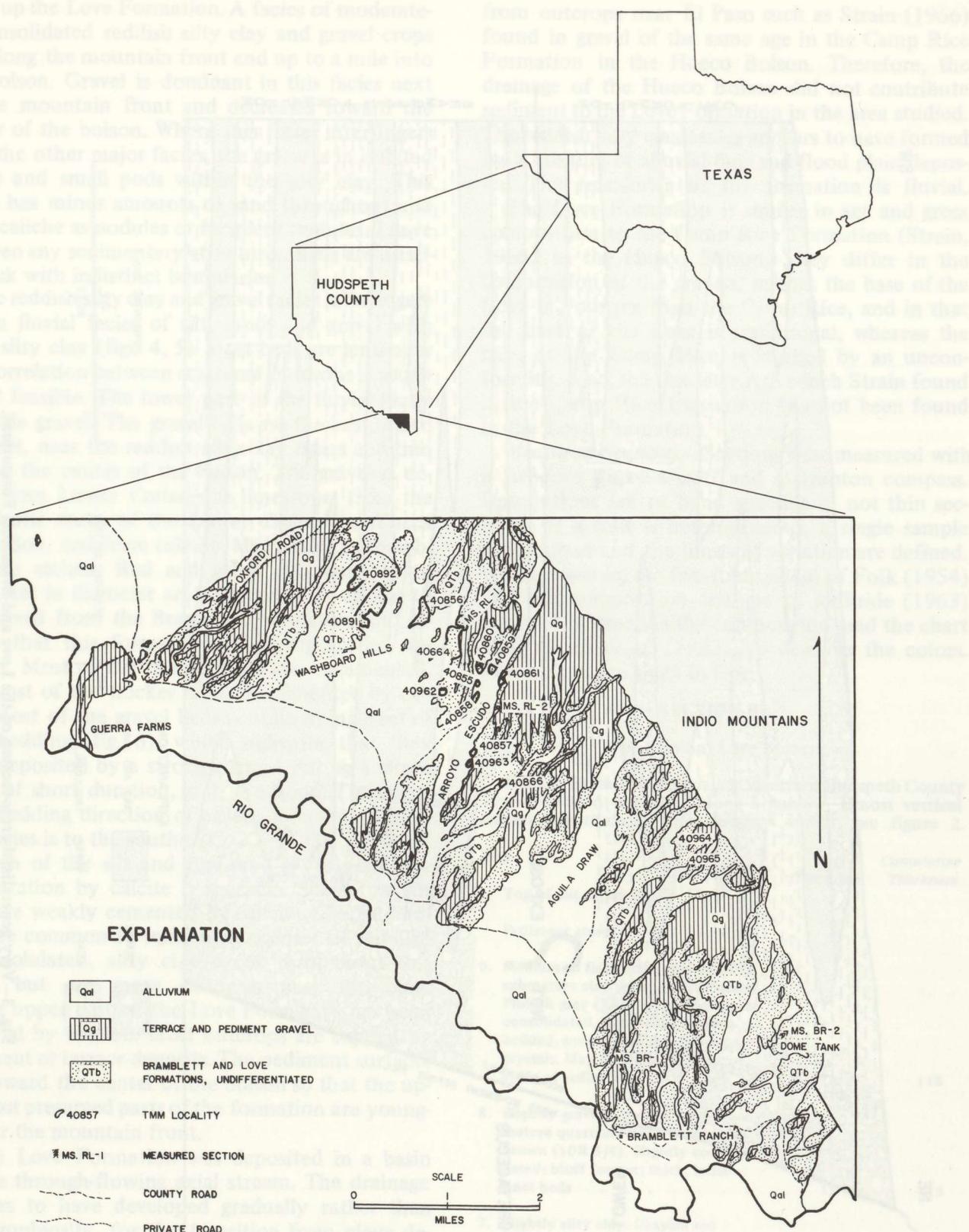


Fig. 2.—Geologic map of a portion of the Red Light Bolson (after Underwood, 1963).

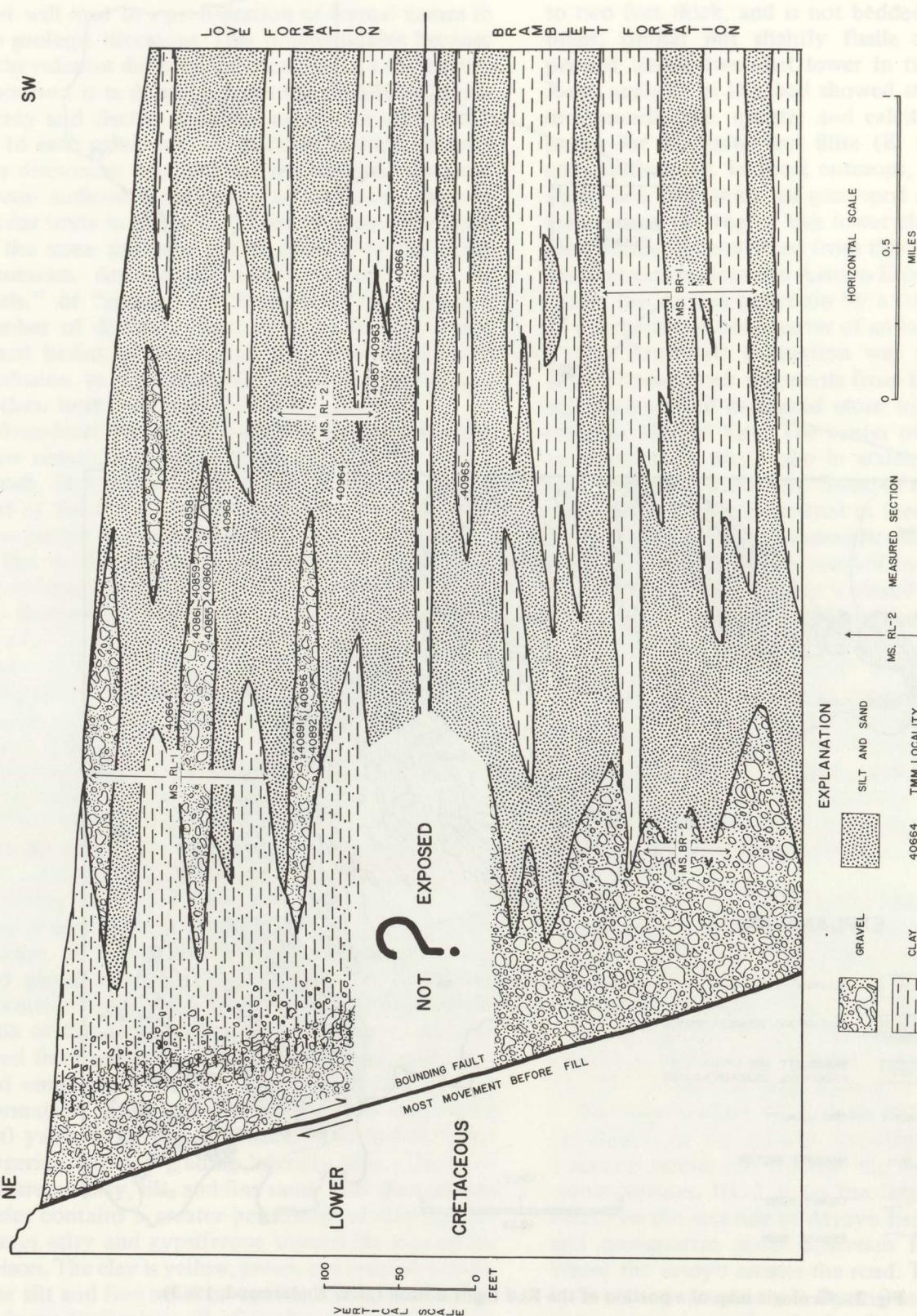


Fig. 3—Very generalized cross-section of the Love and Bramblett Formations.

make up the Love Formation. A facies of moderately consolidated reddish silty clay and gravel crops out along the mountain front and up to a mile into the bolson. Gravel is dominant in this facies next to the mountain front and decreases toward the center of the bolson. Where this facies interfingers with the other major facies, the gravel is in isolated pieces and small pods within the silty clay. This facies has minor amounts of sand throughout and some caliche as nodules or incipient nodules. I have not seen any sedimentary structures. Beds are usually thick with indistinct boundaries.

The reddish silty clay and gravel facies interfingers with a fluvial facies of silt, sand, and gravel with some silty clay (figs. 4, 5). Most beds are lenticular and correlation between scattered outcrops is usually not feasible. The lower part of the fluvial facies has little gravel. The gravel beds are thickest, up to five feet, near the reddish silty clay facies and thin toward the center of the bolson. The gravel is derived from Lower Cretaceous limestone, from the siliciclastic rocks of the Lower Cretaceous Yucca Formation, and from caliche. Many carbonate pebbles are etched. Red and green clay balls up to three feet in diameter are common; they appear to be derived from the Bramblett Formation and indicate that this formation was being eroded upstream. Most of the thinner beds are uncemented, and most of the thicker ones are cemented by calcite. Most of the gravel beds contain a single set of cross-bedding (fig. 6), which indicates that they were deposited by a strong current during a single event of short duration, such as a flood. The major cross-bedding direction of all the sediments within this facies is to the southeast.

Much of the silt and fine sand is cross-bedded. Cementation by calcite is sporadic. Some fine silt beds are weakly cemented by caliche. Caliche nodules are common in some beds. Lenses of reddish, unconsolidated, silty clay occur throughout this facies but are more common near the base.

The upper part of the Love Formation has been removed by erosion. Most outcrops are capped by pediment or terrace deposits. The pediment surfaces dip toward the center of the bolson so that the uppermost preserved parts of the formation are younger near the mountain front.

The Love Formation was deposited in a basin with a through-flowing axial stream. The drainage appears to have developed gradually rather than catastrophically, for the transition from playa deposits to fluvial deposits is gradational. Therefore, I interpret this change to be the result of an increase in rainfall rather than a shift of drainage patterns or stream piracy. The increase of rainfall was, in turn, probably the result of the onset of pluvial conditions. The gravel fraction was derived from Cretaceous outcrops along the bolson and caliche in penecontemporaneous deposits of the bolson. There are no volcanic rock fragments that came

from outcrops near El Paso such as Strain (1966) found in gravel of the same age in the Camp Rice Formation in the Hueco Bolson. Therefore, the drainage of the Hueco Bolson did not contribute sediment to the Love Formation in the area studied. The reddish silty clay facies appears to have formed by a mixture of alluvial fans and flood plain deposits. The remainder of the formation is fluvial.

The Love Formation is similar in age and gross composition to the Camp Rice Formation (Strain, 1966) in the Hueco Bolson. They differ in the composition of the gravels, in that the base of the Love is younger than the Camp Rice, and in that the base of the Love is gradational, whereas the base of the Camp Rice is marked by an unconformity. Also, the Pearlette Ash which Strain found in the Camp Rice Formation has not been found in the Love Formation.

Measured Sections.—Sections were measured with a five-foot Jacob's staff and a Brunton compass. Descriptions are of hand specimens, not thin sections. If a unit is heterogeneous, a single sample is described and the limits of variation are defined. Where possible, the five-fold system of Folk (1954) and the composition triangle of McBride (1963) are used to describe the composition, and the chart of Goddard *et al.* (1963), to describe the colors. Thicknesses are given in feet.

SECTION RL-1

Type Section, Love Formation

John D. Bramblett Ranch, southeastern Hudspeth County Texas. Section measured along a narrow, almost vertical stream cut through TMM locality 40664, see figure 2.

Unit	Unit Thickness	Cumulative Thickness
Top of cut on north side		
Pediment gravel		
9. Medium to fine sandstone, calcitic submature clay pellet sublitharenite. Pinkish gray (5YR 8/1). Moderately consolidated, thin bedded, cross-bedded, several thin units of sand crystals. May be from younger cycle of sedimentation	3	118
8. Slightly gravelly muddy sand, immature quartzarenite. Pale reddish brown (10R 5/4). Slightly consolidated; bluff former; thick, indistinct beds	11	115
7. Slightly silty clay. Grayish red (10R 4/2). Slope former; numerous caliche nodules at base, decreasing upward	15	104
6. Same as Unit 4 but without clay balls and only lenses of caliche gravel	17	89
5. Slightly sandy conglomerate, calcitic submature caliche litharenite. No color determination. Well consolidated, cross-bedded	4	72

Unit	Unit Thickness	Cumulative Thickness
4. Medium sand, mature cherty quartzarenite. Grayish orange pink (10R 8/2). Very heterogeneous unit. Beds, thin to thick; grain size, fine to coarse sand with lenses up to 6 in. of conglomerate and thin clay ball lenses, unconsolidated to consolidated, occasional caliche nodules	32	68
3. Slightly clayey fine to coarse sand, calcitic submature cherty quartzarenite. Grayish orange pink (5YR 7/2). Partially indurated, scattered poorly developed caliche nodules	3	36
2. Slightly sandy clayey siltstone, immature cherty quartzarenite. Pale reddish brown (10R 5/4). Moderately consolidated, bluff former, rare incipient calichification, thin to thick indistinct beds. Contains lenses, pods, and individual particles of coarse sand and gravel	21	33
1. Very fine to fine sand, mature cherty quartzarenite. Grayish orange pink (5YR 7/2). Unconsolidated, cross-bedded. Scattered caliche nodules, gravel, and clay balls	12	12

The base of the section is at the intersection of an arroyo and a tributary which forms a steep, narrow cut through an almost vertical bluff. The section then follows this cut.

SECTION RL-2

Reference Section, Love Formation

John D. Bramblett Ranch, southeastern Hudspeth County, Texas. Section measured on the east side of Arroyo Escudo about two and one-quarter miles upstream from the point where the arroyo crosses the road, see figure 2

Unit	Unit Thickness	Cumulative Thickness
Top of bluff on north side		
6. Medium to fine sand, mature cherty quartzarenite. Grayish pink (5R 8/2). Unconsolidated, contains thin, darker units of clay	8	62.5
5. Silty very fine sand, mature quartzarenite. Grayish orange pink (10R 8/2). Very heterogeneous unit. Contains beds of silt to coarse sand, some indurated, from 1 in. to 2 ft. thick and lenses of caliche gravel. Most units cross-bedded	30.5	54.5
4. Same as Unit 3 but not indurated, slope former	6.5	24
3. Interbedded lithologies of Units 1 and 2. Beds less than 1 ft. thick, some indurated, bluff former	6	17.5
2. Silty clay. Pale red (5R 6/2). Usually blocky but occasionally fissile, bluff former. Contains a few beds up to 2 in. thick of silt as in Unit 1	5.5	11.5
1. Silt, calcitic mature quartzarenite. Grayish orange pink (5YR 7/2). Bluff former. Contains thin beds of clay as in Unit 2	6	6

The base of the section is at the intersection of Arroyo Escudo with a tributary which cuts through a bluff. The section follows this tributary.

SECTION BR-1

Type Section, Bramblett Formation

John D. Bramblett Ranch, southeastern Hudspeth County. Measured in an "amphitheater" about three-quarters of a mile north-northwest of the Bramblett ranchhouse and about one-quarter of a mile northeast of the county road to the ranchhouse, see figure 2.

Unit	Unit Thickness	Cumulative Thickness
Top of hill		
Terrace gravel		
8. Slightly fissile claystone. Pale grayish olive (10Y 5/2). Waxy luster	1.5	76.5
7. Same as Unit 4, slope former	20	75
6. Silt, mature quartzarenite. Pale yellowish brown (10YR 6/2). Slightly indurated, bluff former, cross-bedded. Contains conspicuous layers of heavy minerals and occasional clay laminae	9	55
5. Moderately fissile shale. Moderate brown (5YR 3/4). Salty	2	46
4. Alternating lithologies as in Units 1 and 2. Beds 1 to 4 ft. thick, slope former	33	44
3. Slightly silty clay. Grayish olive (10Y 4/2) and grayish red (10R 4/2) intimately mixed, not in layers	1	11
2. Alternating silt and clay. Pale yellowish brown (10YR 6/2) to moderate brown (5YR 4/4). Slope former, very salty	4	10
1. Clay. Grayish red (10R 4/2). Slope former, very salty	6	6
The base of the section is in the arroyo at the base of a hill which terminates at the arroyo.		
SECTION BR-2		
Reference Section, Bramblett Formation		
John D. Bramblett Ranch, southeastern Hudspeth County, Texas. Section measured about 200 yards northeast of Dome Tank, see figure 2.		
Unit	Unit Thickness	Cumulative Thickness
Top of bluff		
6. Sandy and silty caliche. Grayish orange pink (5YR 7/2). Very resistant. Sand and silt decrease upward. Caliche probably much younger than rest of section	1	55.5
5. Slightly sandy silt, calcareous submature quartzarenite. Light brown (5YR 6/4). Slope former	3	54.5
4. Sandy conglomerate to gravelly		

Unit	Unit Thickness	Cumulative Thickness
coarse sandstone, calcareous submature quartzarenite to litharenite. Grayish orange pink (5YR 7/2). Thick indistinct beds, bluff former. Extremely variable between and within beds	10.5	51.5
3. Gravelly sandstone, calcareous submature quartzarenite to litharenite. Grayish pink (5R 8/2) to grayish orange pink (5YR 7/2). Bluff former, thin to thick beds. Very heterogeneous unit, also contains gravelly clay and silt, silt, and sand	21	41
2. Covered	6	20
1. Coarse sandy silt to silt, calcareous submature cherty quartzarenite. Light brown (5YR 6/4). Slope former	14	14

The base of the section is at the first outcrop below the first bluff northeast of Dome Tank.

STRUCTURE

Underwood (1963) discussed the fault between the bolson fill and the Indio Mountains. The fill, which he described as dipping toward the fault, is the conglomeratic facies of the Bramblett Formation. This dip is in the opposite direction from that which would be expected from drag associated with movement along a gravity fault. There are numerous normal faults in the Love Formation near the mountain front. They dip both toward and away from the mountains. The total displacement of the faults within the Love Formation appears to be less than 100 feet.

Much of the Bramblett Formation is cut by normal faults, each of which appears to have less than 50 feet of displacement. The number of these faults increases toward the center of the bolson. Because the Love Formation has been eroded away, it cannot be determined whether or not the faults cut it also.

A few normal faults with less than 50 feet of displacement and several reverse faults with about a foot of displacement do cut the Love Formation. Most of these are either roughly parallel or perpendicular to the axis of the bolson.

The structure of the fill in the Washboard Hills described by Underwood (1963) resulted from faulting in the Love Formation, where arcuate normal faults are expressed as a series of arcuate ridges. These ridges are well developed in the Washboard Hills and traces of them are visible northeast, north, and northwest of the hills. On the average the faults dip south-southwest, and the strata they cut dip north-northeast. At several localities the faults cut what seem to be the remnants of a pediment gravel. Displacement appears to be on the order of tens of feet. Underwood suggested that the structure resulted from creep toward the

south-southeast.

SYSTEMATIC PALEONTOLOGY

This report gives systematic descriptions only of the mammals from the Red Light local fauna. It lists the Aguila local fauna and the lower vertebrates from the Red Light local fauna. John G. Lundberg of the University of Michigan identified the fish from both faunas. Pierce Brodkorb of the University of Florida is studying the birds from both faunas.

Terminology of horse teeth is after Quinn (1955) and terminology of artiodactyl postcranial material is after Webb (1965).

The Red Light local fauna may be divisible into two faunal units, one from the stratigraphically lower localities and one from the stratigraphically higher localities. The two are quite different but only the microvertebrates are well known from the lower localities and only the larger vertebrates are well known from the higher localities. A similar division is present in the Hudspeth local fauna (Strain, 1966). Tables 1a and 1b are faunal lists of the lower and higher localities of the Red Light local fauna and comparisons with the Hudspeth local fauna. If further study shows that these faunas are different, I propose that the name Red Light local fauna be retained for the fauna from the stratigraphically higher localities.

Locality descriptions.—The Texas Memorial Museum identifies fossil vertebrate localities by the first five-digit number of each specimen, e.g., 40664. The second number of each specimen, e.g., -35, is a serial listing of the specimens from that locality. Therefore, the locality for each TMM specimen, 40664-35, is determined without further description. The systematic section of this paper does not list the locality for each specimen. Instead, the reader is referred to figure 2 for the geographic position of each locality, to figure 3 for the approximate stratigraphic position of each locality, and to the following short descriptions of each locality. The locality descriptions are in numerical order.

TMM 40664, Love Formation, is the most fossiliferous locality. It is a continuous exposure of a thick section, mostly interbedded fluvial silt, sand, and gravel. Much of the gravel and some of the sand is indurated. In the northeast part of TMM 40664 these fluvial sediments are interbedded with reddish silty clay. Some poorly developed caliche is near the base of the section. To the southwest, the gravel beds thin and finer sediment predominates. Measured Section RL-1 is at this locality.

TMM 40855, Love Formation, is a small, isolated outcrop of sand and caliche-gravel. Some fossil material came from it.

TMM 40856, Love Formation, resembles TMM 40664 except that much less section is exposed and the outcrop is a series of small hills. Some fossil





Fig. 6.—Cross-bedded gravel at locality TMM 40664, Love Formation.

material came from it.

TMM 40857, Love Formation, yielded most of the microvertebrate material. Sediments here are fluvial sand and silt with minor amounts of granule-to pebble-size material.

TMM 40858, Love Formation, is a small, isolated outcrop of sand and silt. Little material was collected here.

TMM 40859, 40860, and 40861, Love Formation, are small outcrops of interbedded silt, sand, and gravel resembling those at TMM 40664. Little material was collected at these localities.

TMM 40866, Love Formation, is the stratigraphically lowest locality within the Love Formation. Little material was collected from the fine sand and silt here.

TMM 40891 and 40892, Love Formation, are in extensively faulted fluvial silt, sand, and conglomerate similar to TMM 40856 and 40664. Outcrops are mostly covered with a lag gravel derived from pediment deposits but a few fossils were collected

Fig. 4. (opposite page, top)—View of locality TMM 40664, Love Formation, looking north. Fluvial facies interfingering with reddish silty clay (dark, bluff-forming unit). Dark bed at upper right is younger gravel. Eagle Mountains in back.

Fig. 5. (opposite page, lower)—Closeup of figure 4. R= reddish silty clay, G= gravel.

from good exposures.

TMM 40962, Love Formation, is in fluvial silt and sand with a few thin beds of gravel. The fossil material from this locality came from the lower part of the exposed section, which also bears a few caliche nodules.

TMM 40963, Love Formation, is in clay, silt, and fine sand. It is a small, low outcrop which yielded a small amount of fossil material, mostly microvertebrates.

TMM 40964, Love Formation, is a large area of excellent exposures but very little bone. It is mostly silt and sand with some clay low in the section and some gravel high in the section.

TMM 40965, Bramblett Formation, is the same area as TMM 40964 but is assigned a different number because it is in a different stratigraphic unit. The section is interbedded clay and silt. Microvertebrates were collected from a zone about one inch thick containing numerous plant and gastropod fragments. This zone is within a green clay close to the top of the Bramblett Formation. Fragmentary remains of small fish are common, but other vertebrates are rare.

Aguila local fauna.—The Aguila local fauna was collected from the upper part of the Bramblett Formation. It is named for Aguila Draw near which the collections were made.

Class OSTEICHTHYS

Gila sp.

Class AVES

Unidentified birds

Class MAMMALIA

Order RODENTIA

Gen et sp. indet.

Red Light local fauna.—The Red Light local fauna was collected from the Love Formation. It is named for the Red Light Bolson in which the collections were made.

Class OSTEICHTHYS

Gila nigrescens or *pandora*

Pylodictis olivaris

Small catfish

Class AMPHIBIA

Unidentified anurans

Class REPTILIA

Trionyx sp.

Pseudemys sp.

Geochelone sp.

Gopherus sp.

Terrapene sp.

Phrynosoma sp.

Unidentified lizards and snakes

Class AVES

Odontophorinae, Gen. undet.

Accipitridae, Gen. indet.

Ciconia sp.

Passeriformes, indet.

Class MAMMALIA

Order EDENTATA

Family MEGALONYCHIDAE

Megalonyx sp.

Figure 8, A

Material.—Partial right femur, TMM 40856-47.

Description.—Both the distal and proximal ends of the femur and the proximal part of the third trochanter are missing. The surface of the remaining part of the third trochanter is flat but roughened. It appears to have been quite long, more than 75 mm. The greatest width of the preserved part is 22 mm. The surface of the lesser trochanter is rounded and rough. It is set off from the body of the femur by a groove on the posterior and proximal sides. Maximum width is about 26 mm. A large, roughened muscle attachment is present on the posterior side of the femur at the level of the lesser trochanter. At the level of the third trochanter, the width of the femur is 108 mm and the antero-posterior diameter is 42 mm. The shape and pro-

portions of this specimen are close to the femur from the Hudspeth local fauna that Strain (1966) referred to *Megalonyx*. TMM 40856-47 differs from the specimen of *Megalonyx jeffersoni* figured by Leidy (1855) in that the third trochanter in the latter is a sharp ridge. The specimen is closer to *Megalonyx* than to the other genera of North American ground sloths.

Probable habitat.—*Megalonyx* probably was a browsing, forest-dwelling form, for it is associated with Late Pleistocene forested areas and forest faunas (Stock, 1925; Semken, 1966). The skeleton of *Megalonyx* indicates a slow, ponderous animal.

Family MYLODONTIDAE

Paramylodon sp.

Figure 8, B, C

Material.—Two caniniform (1st anterior) teeth, TMM 40855-12 and -33; fragmentary right mandible, TMM 40664-295; ungual phalange, TMM 40664-10.

Description.—The first listed caniniform tooth, TMM 40855-12, is more strongly curved and smaller than corresponding teeth from Ingleside Pit, Texas, referred to *Paramylodon harlani* by Lundelius (in manuscript). It is similar to this material in that the cross-section is a very rounded triangle and in having a series of fine, parallel, undulating transverse lines on the external surface of the tooth. The greatest transverse diameter is 12.8 mm, the greatest anteroposterior diameter is 14.0 mm, and the length along the outside of the curve is 90 mm. The wear facet is flat and slants only slightly posterior relative to the long axis of the tooth. The strong curvature and small size indicate that it is probably an upper tooth from a young animal.

The other caniniform tooth, TMM 40855-33, is larger in diameter and less strongly curved. It is probably an upper tooth from an individual larger than the one represented by the other caniniform tooth. The basal portion is missing. The cross-section has the same shape as the previously described tooth but the lines are not present on the external surface. They may have been removed by stream abrasion. The greatest anteroposterior diameter is 19.2 mm and the greatest transverse diameter is 14.8 mm. The wear facet slants posteriorly and is slightly concave.

The fragmentary right mandible is severely weathered and broken. Only the area around the alveolus for the fourth lower tooth is preserved. The fourth lower tooth is highly variable in *Paramylodon harlani* (Stock, 1925). The shape of the alveolus in TMM 40664-295 is within the range of variation for *Paramylodon harlani* but it is smaller than most. Accurate measurements are impossible. The mandible fragment is smaller than material of *Paramylodon harlani* from the Ingleside fauna. The small process on the lingual side posterior to the fourth

TABLE 1a

COMPARISON OF THE LOWER PART OF THE RED LIGHT LOCAL FAUNA AND THE HUDSPETH LOCAL FAUNA OF THE FORT HANCOCK FORMATION

RED LIGHT LOCAL FAUNA (lower part)	HUDSPETH LOCAL FAUNA OF FT. HANCOCK FORMATION (Strain, 1966)
Class OSTEICHTHYS <i>Gila nigrescens</i> or <i>pandora</i> Small catfish	
Class AMPHIBIA Unidentified anurans	
Class REPTILIA	Testudinidae gen. sp. undet. <i>Gopherus huecoensis</i>
Unidentified turtle <i>Phrynosoma</i> sp. Unidentified lizards and snakes	
Class AVES	
Odontophorinae, Gen. undet. Passeriformes, indet.	
Class MAMMALIA	
<i>Geomys (Nerterogeomys)</i> <i>paenebursarius</i> <i>Prodipodomys</i> sp. <i>Perognathus</i> sp. <i>Onychomys</i> sp. <i>Sigmodon hudspethensis</i>	<i>Scalopus</i> sp. <i>Geomys paenebursarius</i> <i>Sigmodon hudspethensis</i> <i>Citellus mcghee</i> <i>Citellus finlayensis</i>
<i>Nannippus phlegon</i> <i>Nannippus</i> cf. <i>minor</i> <i>Equus</i> sp. Mastodont indet. Large camel Small artiodactyl Leporidae, 2 types indet.	Leporidae gen. sp. undet.

tooth is much less developed in TMM 40664-295 than in *Paramylodon harlani*.

The ungual phalange is broken just posterior to the subungual foramina and the sheath is missing. The shape and cross-section are similar to those of *Paramylodon harlani* described by Stock (1925). Length from the subungual foramen to the distal tip is 58 mm and the greatest width is 21.4 mm.

Probable habitat.—Stock (1925) suggested that this genus inhabited open country. He based this interpretation on skeletal characteristics, the presence of dermal ossicles, and associated faunas. The simple dentition suggests that it was a browser.

Family GLYPTODONTIDAE

Glyptotherium texanum Osborn, 1903
Figure 8, D, E; figure 9, A, B

Material.—Partial carapace, TMM 40962-1; numerous isolated scutes; distal end of right humerus, TMM 40664-245; right anterior ungual phalange, TMM 40664-109.

Description.—Only about one-third of the carapace is preserved. It includes the anterior portion and the portion of the left side that has the iliac

TABLE 1b

COMPARISON OF THE UPPER PART OF THE RED LIGHT LOCAL FAUNA AND THE HUDSPETH LOCAL FAUNA OF THE CAMP RICE FORMATION

RED LIGHT LOCAL FAUNA	HUDSPETH LOCAL FAUNA OF CAMP RICE FORMATION (Strain, 1966)
Class OSTEICHTHYS <i>Ptylodictis olivaris</i>	
Class REPTILIA	
<i>Trionyx</i> sp. <i>Pseudemys</i> sp. <i>Geochelone</i> sp. <i>Gopherus</i> sp. <i>Terrapene</i> sp.	Testudinidae gen. sp. undet.
Class AVES	
<i>Ciconia</i> sp. Accipitridae, Gen. indet.	
Class MAMMALIA	
<i>Megalonyx</i> sp. <i>Paramylodon</i> sp. <i>Glyptotherium texanum</i> <i>Cratogeomys</i> sp. Unidentified rodents <i>Urocyon</i> cf. <i>progressus</i> <i>Canis</i> cf. <i>leopodus</i> <i>Borophagus</i> sp. <i>Ischyrusmilus</i> sp. <i>Felis</i> cf. <i>rrexroadensis</i> <i>Taxidea</i> sp. Mastodont indet. Leporidae indet. <i>Platygonus bicalcaratus</i> <i>Tanupolama</i> sp. <i>Tanupolama</i> cf. <i>blancoensis</i> Undescribed long-limbed camel <i>Camelops</i> sp.	<i>Megalonyx</i> sp. <i>Glyptotherium</i> sp. <i>Tanupolama</i> sp. <i>Gigantocamelus</i> sp. <i>Odocoileus</i> sp. <i>Equus (Plesippus) idahoensis</i> <i>Equus (Plesippus) simplicidens</i> <i>Asinus</i> cf. <i>cumminsi</i> <i>Nannippus phlegon</i> <i>Tapirus</i> cf. <i>copei</i>

and ischiac attachments. The only marginal area preserved is in the nuchal region. Part of it was destroyed prior to burial and part during exhumation along an arroyo. Scutes and calichified portions of the carapace were recovered from the arroyo. The specimen was upright when found with the long axis of the carapace about perpendicular to the current direction which prevailed during deposition of the Red Light Formation. Sediments within the carapace dipped upstream. The right side of the carapace had folded under the specimen and is so extensively calichified that the scute pattern is largely destroyed. On the external surface is a thick band of caliche, two to six inches wide, which almost completely encircles the preserved portion. Numerous cracks distort the specimen. At present most of the external surface is unprepared.

The nonmarginal scutes are usually hexagonal and arranged in transverse rows across the carapace.



Fig. 7.—Silt and clay of the Bramblett Formation at the type section

The surface of the scutes is punctate. They are about 30 to 50 mm in diameter as measured across parallel sides of the scutes. The central figures of these scutes are round to faintly polygonal and the surfaces of these figures are flat or slightly depressed. The diameters of the central figures are 50 percent or more of the diameters of the scutes. There are seven to nine marginal figures on each scute, seven being rare. They are clearly separated from each other and from the central figure by grooves in each scute but are continuous between scutes. They are punctate and do not show radial sculpturing. There are usually two to four hair follicles per scute in the groove between the central and marginal figures.

The three nuchal scutes preserved are small. Their lengths are about 25 mm, widths are about 25 mm, and thicknesses are about 19 mm. They are five sided with one suture on each of the lateral and anterior edges and two sutures on the posterior edge of each scute. The anterior margin is almost straight. The central figure is flat and raised well above the very narrow marginal area. No marginal figures are present and punctuation is reduced. A distinct groove is anterior to the central figure. Between the nuchal scutes and the main carapace scutes is a row of small, almost square scutes. The centers of these and the adjacent row of carapace

scutes are deeply depressed. Lateral to the nuchal area, rows of small, square to irregular scutes are intercalated between the nuchal and main carapace scutes.

Several posterior marginal scutes were found in the arroyo which cut through the specimen. These are very thick, up to 30 mm, and large. The central figure occupies most of the scute except for a narrow marginal area on the internal side. There are also several scutes from the main carapace rows next to the posterior marginals. These are similar except that the narrow marginal area extends completely around the scute. The centers of the central figures are slightly depressed.

The attachment for the left ilium is 20 cm long, about 7 cm in greatest width, and about 73 cm in a straight line from the nuchal edge of the carapace. It is oriented almost perpendicular to the midline of the carapace. A portion of the attachments for the right ilium and the neural ridge of the sacrum are present. The attachment for the left ischium is aligned almost parallel to the midline of the specimen. It is about 3 cm wide and 15 cm long but it may not be complete. The anterior end is about 94 cm in a straight line from the nuchal edge of the carapace.

This specimen is assigned to *Glyptotherium texanum* Osborn because the scutes are arranged in

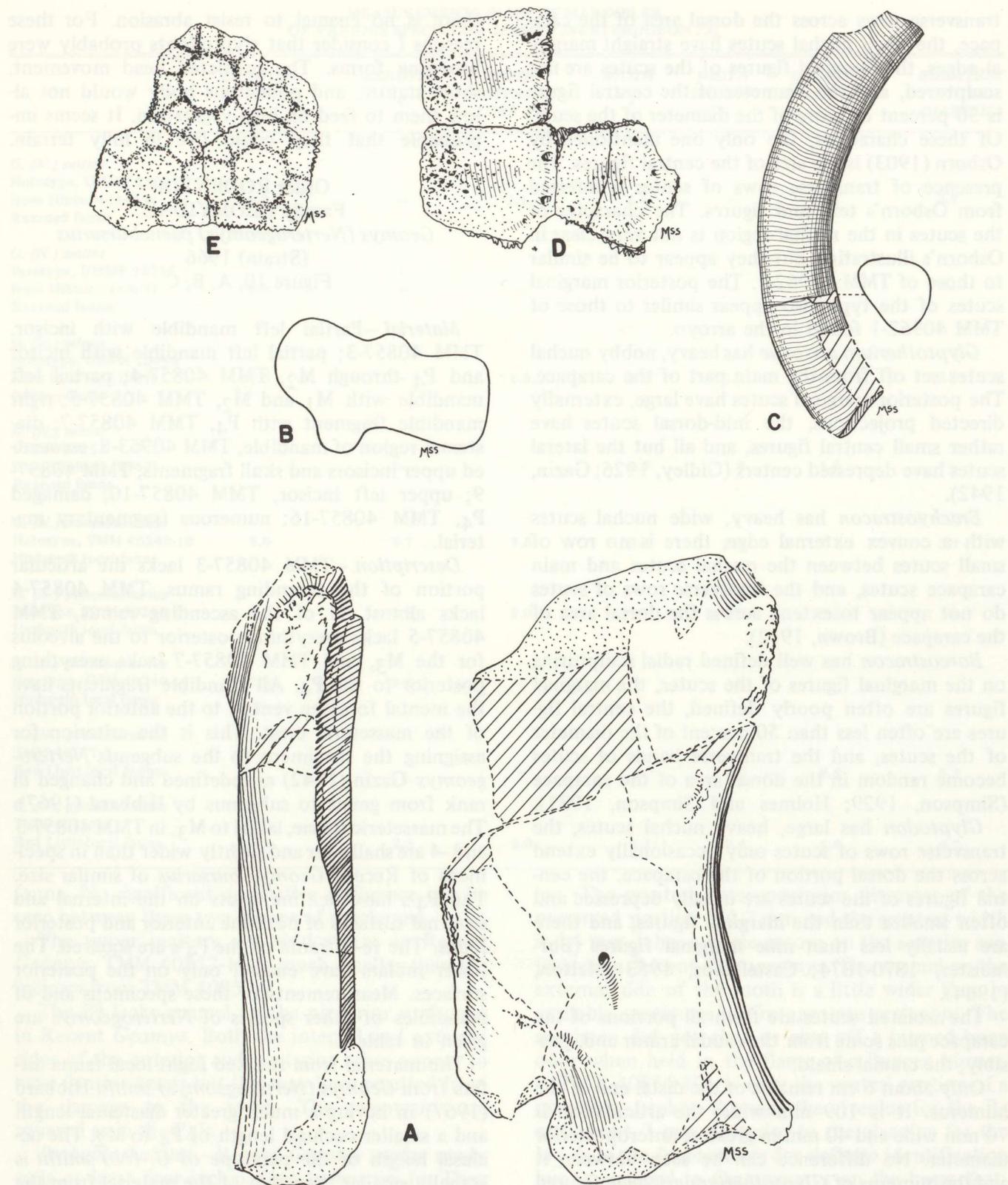


Fig. 8.—A. *Megalonyx* sp., partial right femur, TMM 40856-47, internal and anterior views ($X\frac{1}{2}$).
 B. *Paramylodon* sp., outline of alveolus for fourth lower tooth, TMM 40664-295 ($X1$).
 C. *Paramylodon* sp., caniniform tooth, TMM 40855-12, side view and cross-section ($X1$).
 D. *Glyptotherium texanum*, posterior marginal scutes, TMM 40962-1, external view ($X\frac{1}{2}$).
 E. *Glyptotherium texanum*, main carapace scutes, TMM 40962-1, external view ($X\frac{1}{2}$).

transverse rows across the dorsal area of the carapace, the small nuchal scutes have straight marginal edges, the marginal figures of the scutes are not sculptured, and the diameter of the central figure is 50 percent or more of the diameter of the scute. Of these characters, the only one mentioned by Osborn (1903) is the size of the central figures. The presence of transverse rows of scutes is inferred from Osborn's text and figures. The character of the scutes in the nuchal region is not very clear in Osborn's illustration but they appear to be similar to those of TMM 40962-1. The posterior marginal scutes of the type also appear similar to those of TMM 40962-1 found in the arroyo.

Glyptotherium arizonae has heavy, nobby nuchal scutes set off from the main part of the carapace. The posterior marginal scutes have large, externally directed projections, the mid-dorsal scutes have rather small central figures, and all but the lateral scutes have depressed centers (Gidley, 1926; Gazin, 1942).

Brachyostracon has heavy, wide nuchal scutes with a convex external edge, there is no row of small scutes between the nuchal scutes and main carapace scutes, and the transverse rows of scutes do not appear to extend across the dorsal area of the carapace (Brown, 1912).

Boreostracon has well defined radial sculpturing on the marginal figures of the scutes, the marginal figures are often poorly defined, the central figures are often less than 50 percent of the diameter of the scutes, and the transverse bands of scutes become random in the dorsal area of the carapace (Simpson, 1929; Holmes and Simpson, 1931).

Glyptodon has large, heavy nuchal scutes, the transverse rows of scutes only occasionally extend across the dorsal portion of the carapace, the central figures of the scutes are usually depressed and often smaller than the marginal figures, and there are usually less than nine marginal figures (Burmeister, 1870-1874; Castellanos, 1953; Melton, 1964).

The isolated scutes are from all portions of the carapace plus some from the caudal armor and, possibly, the cranial shield.

Only about 6 cm remains of the distal end of the humerus. It is 109 mm wide; the articulation is 70 mm wide and 40 mm in greatest anteroposterior diameter. No difference can be seen between it and the humerus of *Glyptotherium arizonae* figured by Gidley (1926).

The ungual phalange is broad and flattened. It is 80 mm long. The proximal end is 43 mm wide and 37 mm in anteroposterior diameter.

Probable habitat.—The dentition of glyptodonts is complex and hypsodont as in many grazing mammals. However, there is no enamel on the teeth and they appear to lack a mechanism to crop grass. If they had grazed, the cheek teeth would have had to grow extremely fast to make up for wear since

there is no enamel to resist abrasion. For these reasons I consider that glyptodonts probably were browsing forms. The restricted head movement, short stature, and ponderous body would not allow them to feed on high vegetation. It seems improbable that they could live in hilly terrain.

Order RODENTIA
Family GEOMYIDAE
Geomys (Nerterogeomys) paenebursarius
(Strain) 1966
Figure 10, A, B, C

Material.—Partial left mandible with incisor, TMM 40857-3; partial left mandible with incisor and P₄ through M₂, TMM 40857-4; partial left mandible with M₁ and M₂, TMM 40857-5; right mandible fragment with P₄, TMM 40857-7; diastemal region of mandible, TMM 40963-8; associated upper incisors and skull fragments, TMM 40857-9; upper left incisor, TMM 40857-10; damaged P₄, TMM 40857-16; numerous fragmentary material.

Description.—TMM 40857-3 lacks the articular portion of the ascending ramus, TMM 40857-4 lacks almost all of the ascending ramus, TMM 40857-5 lacks everything posterior to the alveolus for the M₃, and TMM 40857-7 lacks everything posterior to the P₄. All mandible fragments have the mental foramen ventral to the anterior portion of the masseteric crest. This is the criterion for assigning the specimens to the subgenus *Nerterogeomys* Gazin (1942) as redefined and changed in rank from genus to subgenus by Hibbard (1967). The masseteric fossae, labial to M₃, in TMM 40857-3 and -4 are shallower and slightly wider than in specimens of Recent *Geomys bursarius* of similar size. The P₄'s have dentine tracts on the internal and external surfaces of both the anterior and posterior lophs. The re-entrants on the P₄'s are squared. The lower molars have enamel only on the posterior surfaces. Measurements of these specimens and of mandibles of other species of *Nerterogeomys* are given in table 2.

The material from the Red Light local fauna differs from *Geomys (Nerterogeomys) smithi* Hibbard (1967) in having a much greater diastemal length and a smaller occlusal length of P₄ to M₂. The occlusal length of the paratype of *G. (N.) smithi* is actually smaller than that of the material from the Red Light local fauna, but it is from a very immature individual. The Red Light specimens are larger than *G. (N.) minor* (Gidley) (1922) in all measurements. *Geomys (N.) paenebursarius* (Strain) (1966) is very close to the Red Light specimens except that the length of the diastema in the former is slightly smaller. The holotype and paratype specimens of *G. (N.) paenebursarius* from which this measurement can be taken appear to be younger individuals than those from the Red Light local

TABLE 2

MEASUREMENTS IN MM OF MANDIBLES
OF VARIOUS SPECIES OF *GEOMYS (NERTEROGEOMYS)*

	LENGTH <i>P₄</i> to <i>M₂</i>	LENGTH <i>P₄</i>	WIDTH, POSTERIOR LOBE <i>P₄</i>	WIDTH <i>M₁</i>	WIDTH <i>INCISOR</i>	LENGTH <i>DIASTEMA</i>	GREATEST WIDTH <i>DIASTEMA</i>
<i>G. (N.) smithi</i> Holotype, UMMP 25095 from Hibbard (1967) Rexroad fauna	5.9	—	2.1	2.4	—	6.0	3.9
<i>G. (N.) smithi</i> Paratype, UMMP 28258 from Hibbard (1967) Rexroad fauna	5.0	—	—	—	—	—	—
<i>G. (N.) minor</i> Holotype, USNM 10498 from Hibbard (1967) Benson fauna	5.0	—	1.9	2.0	2.1	5.4	3.5
<i>G. (N.) minor</i> UMMP 29156 from Hibbard (1967) Rexroad fauna	—	—	—	1.7	1.9	5.0	—
<i>G. (N.) paenebursarius</i> Holotype, TMM 40240-10 Hudspeth local fauna	5.0	2.7	2.0	2.4	2.6	7.3	3.7
<i>G. (N.) paenebursarius</i> Paratype, TMM 40240-14 Hudspeth local fauna	5.0	2.5	2.0	—	2.3	7.2	3.8
<i>G. (N.) paenebursarius</i> Paratype, TMM 40240-19 Hudspeth local fauna	5.2	2.4	—	—	—	—	—
<i>G. (N.) paenebursarius</i> TMM 40857-3 Red Light local fauna	—	—	—	—	2.3	9.6	4.3
<i>G. (N.) paenebursarius</i> TMM 40857-4 Red Light local fauna	5.1	2.5	2.0	2.1	2.4	8.0	4.2

fauna. No significant qualitative difference can be seen between these two groups of specimens.

The upper incisors are bisulcate as in Recent *Geomys*. TMM 40857-10 is much smaller than the incisors from TMM 40857-9.

The *P₄* lacks enamel on the posterior surface as in Recent *Geomys*. Both the internal and external sides of the anterior and posterior lobes appear to have dentine tracts but this may have resulted from the damage to the tooth. The re-entrants are squared as in the *P₄*'s.

Probable habitat.—Recent *Geomys* prefer sandy soils at least four inches deep to burrow in. They eat a wide variety of vegetable matter and a few insects (Davis, 1960).

Cratogeomys sp.
Figure 11, A

Material.—Upper left incisor, TMM 40664-290; left mandible fragment, TMM 40856-101.

Description.—The root area of the incisor is miss-

ing. The greatest anteroposterior diameter of the preserved portion is 4.7 mm and the greatest width is 4.4 mm. It has a single groove on the anterior surface as in Recent *Cratogeomys*. The enamel on the external side of the tooth is a little wider than in available specimens of *Cratogeomys castenops*. The specimen did not char or give off a burned bone odor when held in the flame of a Bunsen burner.

TMM 40856-101 is only the ventral portion of a mandible, broken through the alveolus for the *P₄* and about 7 mm posterior to the alveolus for the *M₃*. It is too fragmentary for definite identification but is assigned to *Cratogeomys* on the bases that it is from a gopher about the same size as that indicated by the incisor discussed above and is from the same stratigraphic interval as the incisor.

Probable habitat.—Recent *Cratogeomys castenops* feed on roots, stems, and bark, and prefer deep, rock-free soils. According to Davis (1960), this animal can live in soils containing considerable clay. Davis also remarked that *Geomys* and *Cratogeomys* inhabit mutually exclusive environments with *Geomys* living in soil containing little clay.

Family HETEROMYIDAE

Prodipodomys sp.

Figure 11, B

Material.—Left M₁, TMM 40857-13.

Description.—The tooth is unworn except for slight abrasion of the cusps, probably resulting from the screening procedure. The greatest length of the tooth is 1.11 mm and the greatest width is 1.83 mm. There is no sign of dentine tracts along the sides of the tooth. Absence of a dentine tract is the primary feature which distinguishes *Prodipodomys* from *Dipodomys* (Hibbard, 1962).

Cusp nomenclature is from Wood and Wilson (1936). The hypolophid is sharp, thin, and nearly straight. The hypostylid, hypoconid, and entoconid are well defined, sharp cusps on the hypolophid. The hypoconid is much closer to the hypostylid than to the entoconid. The metalophid is sharp, higher than the hypolophid, and convex posteriorly. The three anterior cusps—metaconid, protoconid, and protostylid—are on the metalophid and are well developed. Anterior to the metalophid is another sharp but lower loph connecting the metaconid and protostylid. It is concave posteriorly. This loph and the metalophid enclose a depression which is pointed at the metaconid and rounded at the protostylid. The hypoconid is connected to the protoconid by a low ridge and the hypostylid is connected to the protostylid by a higher ridge. These four cusps enclose a small depression, part of the median valley.

This specimen is larger than *Prodipodomys rexroadensis* Hibbard (1954) and about the size of a *Prodipodomys* sp. from the Sanders local fauna (Hibbard, 1956). The configuration of the occlusal surface is similar to that of a molar in the Sanders material. Specific assignment cannot be made until additional material is collected.

Probable habitat.—The Recent kangaroo rats, *Dipodomys*, are primarily desert and wasteland inhabitants. They eat mostly seeds but sometimes also take green vegetation (Davis, 1960). Most species do not require water but are able to make use of metabolic water. Of all the rodents in North America, they are the best adapted to desert life. These data do not necessarily mean that *Prodipodomys* lived in a desert. The association of moist-climate mammals and mollusks with *Prodipodomys* in the Sanders and Rexroad local faunas shows that this genus was not restricted to arid environments.

Perognathus sp.

Figure 11, C

Material.—Left P₄, TMM 40857-14.

Description.—The tooth is only slightly worn. Measurements are: greatest length, 0.94 mm and greatest width, 1.08 mm. It is intermediate in size between *Perognathus merriami* and *P. hispidus* and about the size of *P. penicillatus*. Cusp morphology does not differ from that of Recent species of *Perognathus*. The morphology of the P₄ is not diagnostic in distinguishing the species of this genus.

Probable habitat.—Pocket mice feed almost ex-

clusively on seeds and low woody growth (Davis, 1960). They are widespread in the western United States and Mexico but usually prefer arid to semiarid lands (Hall and Kelson, 1959).

Family CRICETIDAE

Onychomys sp.

Figure 11, D

Material.—Left M₁, TMM 40857-12.

Description.—The specimen is moderately worn; the greatest length is 1.83 mm and the greatest width is 1.15 mm. It is about the size of the Recent *Onychomys leucogaster* but differs from it in being lower crowned. Also, the anteroexternal re-entrant between the anteroconid and the protoconid is narrow and has a straight anterior border oriented at right angles to the long axis of the tooth. This re-entrant in the *O. leucogaster* is wider and has a rounded anterior border directed posterointernally. TMM 40857-12 differs from *O. fossilis* Hibbard (1941a), from the Borchers fauna, in these same respects and in having the re-entrant between the entoconid and metaconid almost exactly opposite the protoconid rather than anterior to it as in *O. fossilis*. TMM 40857-12 is almost identical to a specimen of *O. gidleyi* Hibbard (1941b) from the Rexroad fauna but since the M₃ is the most diagnostic tooth in determining species of *Onychomys*, it cannot be referred with any confidence.

Probable habitat.—*Onychomys* feeds primarily on insects but will occasionally eat plant material (Davis, 1960) and other rodents (Hall and Kelson, 1959). Most species inhabit arid and semiarid regions of the western United States and Mexico.

Sigmodon hudspethensis Strain, 1966

Figure 11, E, F

Material.—Partial left mandible with partial incisor and M₁ through M₃, TMM 40857-10; unworn left M₁, TMM 40857-11.

Description.—The mandible is broken through the diastema and several millimeters posterior to the M₃. The portion ventral to the incisor is also missing. The isolated left M₁ shows slight abrasion of the highest points. Both specimens have typical *Sigmodon* cusp patterns, although the folds are not as tight as in Recent species. They fit completely Strain's (1966) description of *Sigmodon hudspethensis* and comparison of the specimens shows that they are most probably conspecific.

In the type description of *Sigmodon hudspethensis*, one of the criteria used to separate it from *S. intermedius* is that the anteroexternal re-entrant of the M₁ in the former is deeper and not closed to the outside. The M₁ of the type of *S. intermedius* (Hibbard, 1938) does have a shallower anteroexternal re-entrant which is closed to the outside but this specimen is heavily worn. Topotype material of *S. intermedius* is very similar to *S. hudspethensis* in these two characteristics if not heavily worn. There is also a low enamel ridge across the opening of this re-entrant in all specimens of *S. hudspethensis* examined. This would close the re-

entrant at a very extreme state of wear. The re-entrant in *S. intermedius* closes at an earlier state of wear.

There are several other differences between *Sigmodon hudspethensis* and *S. intermedius*. The enamel folds in the former are tighter and their sides are more nearly parallel. This tighter folding is an advanced characteristic. No mandibles are in the type series described by Strain (1966). The mandible from the Red Light local fauna has the alveolar region elevated considerably above the masseteric valley whereas the mandibles of *S. intermedius* do not. More material is necessary to determine if this characteristic is consistent in *S. hudspethensis*. Comparative measurements of the lower dentitions of *S. hudspethensis* and *S. intermedius* are given in table 3. The sample is small but the measurements of the length of M_1 , width of M_3 , and length of M_3 are slightly larger in *S. hudspethensis*. The most diagnostic measurement is the width of the incisor which is much greater in *S. hudspethensis*.

Probable habitat.—Recent species of *Sigmodon* are grazers and prefer warm climates.

Order CARNIVORA
Family CANIDAE
Urocyon cf. progressus Stevens, 1965
Figure 12, A

Material.—Part of a left mandible with alveoli of P_4 through M_3 , TMM 40855-15.

Description.—The specimen is broken anterior to the P_4 and posterior to the subangular notch. It is more massive than *Urocyon cinereoargenteus* and the subangular notch is more posterior. The depth

of the mandible below the molars increases more markedly in a posterior direction than in the modern species. No other qualitative differences between the fossil and Recent specimens could be determined. Table 4 gives the measurements of the fossil specimen and comparative measurements for a small sample of Recent *U. cinereoargenteus* from Texas and an unusually large Recent specimen from Indiana. The alveolar lengths of each tooth in TMM 40855-15, except the M_3 , are within the range of Recent specimens. The fossil is larger in all other measurements except that the alveolar length from the P_4 to the M_3 is equaled by the large specimen from Indiana.

The type material of *Urocyon progressus* Stevens, from the upper Pliocene Rexroad fauna of Meade County, Kansas, does not include a mandible (Stevens, 1965). This material—a left parietal, a left M_1 , and an incomplete left tibia—is also from a gray fox larger than *U. cinereoargenteus*. This is the basis for tentatively referring the mandible to *U. progressus*. *Urocyon atwaterensis* Getz (1960) is a smaller animal.

Probable habitat.—The Recent gray fox prefers brushy or wooded area and rarely ventures into open country. He is omnivorous, eating mostly birds and small animals, but he occasionally includes fruits, nuts, insects, and crayfish in his diet (Davis, 1960). *Urocyon cf. progressus* probably had similar habits.

Canis cf. lepopagrus Johnston, 1938
Figure 12, B

Material.—Partial right mandible with alveoli or roots of C through P_4 , TMM 40664-3; fragment of

TABLE 3
MEASUREMENTS IN MM OF LOWER DENTITIONS OF SIGMODON

	LENGTH M_1	WIDTH M_1	LENGTH M_2	WIDTH M_2	LENGTH M_3	WIDTH M_3	WIDTH LOWER INCISOR
<i>Sigmodon hudspethensis</i> TMM 40240-1, Holotype Hudspeth local fauna	2.21	1.44	1.58	1.54	—	—	—
<i>Sigmodon hudspethensis</i> TMM 40240-2, Paratype Hudspeth local fauna	2.22	1.47	—	1.67	1.82	1.65	1.36
<i>Sigmodon hudspethensis</i> TMM 40857-10 Red Light local fauna	2.16	1.42	1.67	1.62	1.93	1.68	1.34
<i>Sigmodon hudspethensis</i> TMM 40857-11 Red Light local fauna	2.32	1.42	—	—	—	—	—
<i>Sigmodon intermedius</i> UMMP 41193, 3 spec. Rexroad Loc. No. 3	2.05	1.32	1.74	1.63	1.68	1.42	1.05
	—	1.16	1.58	1.32	1.58	1.32	1.00
	—	—	—	—	—	—	1.00

left mandible with roots of P_1 , P_2 , TMM 40664-9; partial right radius, TMM 40664-11; right metacarpal II, TMM 40664-11.

Description.—The partial right mandible is broken at the anterior alveolus of the M_1 and at the anterior part of the canine. The roots of the C , P_2 , and P_4 are present. Some traces of the alveoli for the incisors are visible.

The fragment of left mandible is broken through the canine alveolus and the anterior alveolus for the P_3 . The ventral portion of the specimen is also missing.

Measurements of these specimens, a sample of *Canis lepophagus* from the Cita Canyon fauna, and a Recent sample of *C. latrans* from Texas are given in table 5. Measurements taken are only those which could be obtained for the material from the Red Light local fauna. The alveolar lengths of the individual premolars and of the premolar series are generally larger in *C. lepophagus* than in *C. latrans* as is the depth of the mandible. The measurements of the material from the Red Light local fauna are closer to *C. lepophagus*. In TMM 40664-3 and four out of the five *C. lepophagus* in which both

TABLE 4
MEASUREMENTS IN MM FROM THE LEFT MANDIBLES
OF SEVERAL SPECIES OF *UROCYON*

	ALVEOLAR LENGTH P_4 to M_3	ALVEOLAR LENGTH P_4	ALVEOLAR LENGTH M_1	ALVEOLAR LENGTH M_2	ALVEOLAR LENGTH M_3	DEPTH OF MANDIBLE UNDER M_2 (lingual)	LENGTH POST. ALV. OF M_3 TO SUB- ANGULAR NOTCH (parallel to base of mandible)
<i>Urocyon cf. progressus</i> TMM 40855-15 Red Light local fauna	31.5	6.6	11.4	6.7	3.0	14.4	20.5
<i>Urocyon cinereoargenteus</i> Observed range of ten TMM recent specimens from Texas	26.4 to 30.2	6.0 to 7.7	10.4 to 11.3	5.7 to 7.4	1.5 to 2.4	9.9 to 12.2	12.8 to 18.4
<i>Urocyon cinereoargenteus</i> Large specimen from Indiana. MSS 20	31.6	—	12.0	6.3	2.3	13.2	16.8

TABLE 5
MEASUREMENTS IN MM OF MANDIBLES OF *CANIS*.
NUMBERS IN PARENTHESSES SHOW SIZE OF SAMPLE
WHERE SMALLER THAN TOTAL SAMPLE

	ALVEOLAR LENGTH P_1	ALVEOLAR LENGTH P_2	ALVEOLAR LENGTH P_3	ALVEOLAR LENGTH P_4	ALVEOLAR LENGTH P_1 to P_4	DEPTH OF MANDIBLE BETWEEN P_1 and P_2	DEPTH OF MANDIBLE BETWEEN P_2 and P_3	DEPTH OF MANDIBLE BETWEEN P_3 and P_4
<i>Canis cf. lepophagus</i> TMM 40664-3 Red Light local fauna	4.4	9.5	11.3	11.7	43.9	15.8	16.0	18.3
<i>Canis cf. lepophagus</i> TMM 40664-9 Red Light local fauna	5.3	9.1	—	—	—	—	—	—
<i>Canis lepophagus</i> Observed range of 7 specimens Cita Canyon fauna	4.1-5.3 (6)	8.7-10.8	10.5-12.1 (6)	11.0-13.4	41.2-45.0 (5)	16.0-17.6 (6)	15.5-18.8 (6)	16.6-18.8 (6)
<i>Canis latrans</i> Observed range of 20 Recent speci- mens from Texas	3.5-4.9	7.9-10.0	9.3-11.5	10.4-12.1	37.6-44.8	13.7-16.7	13.2-17.3	14.3-18.2

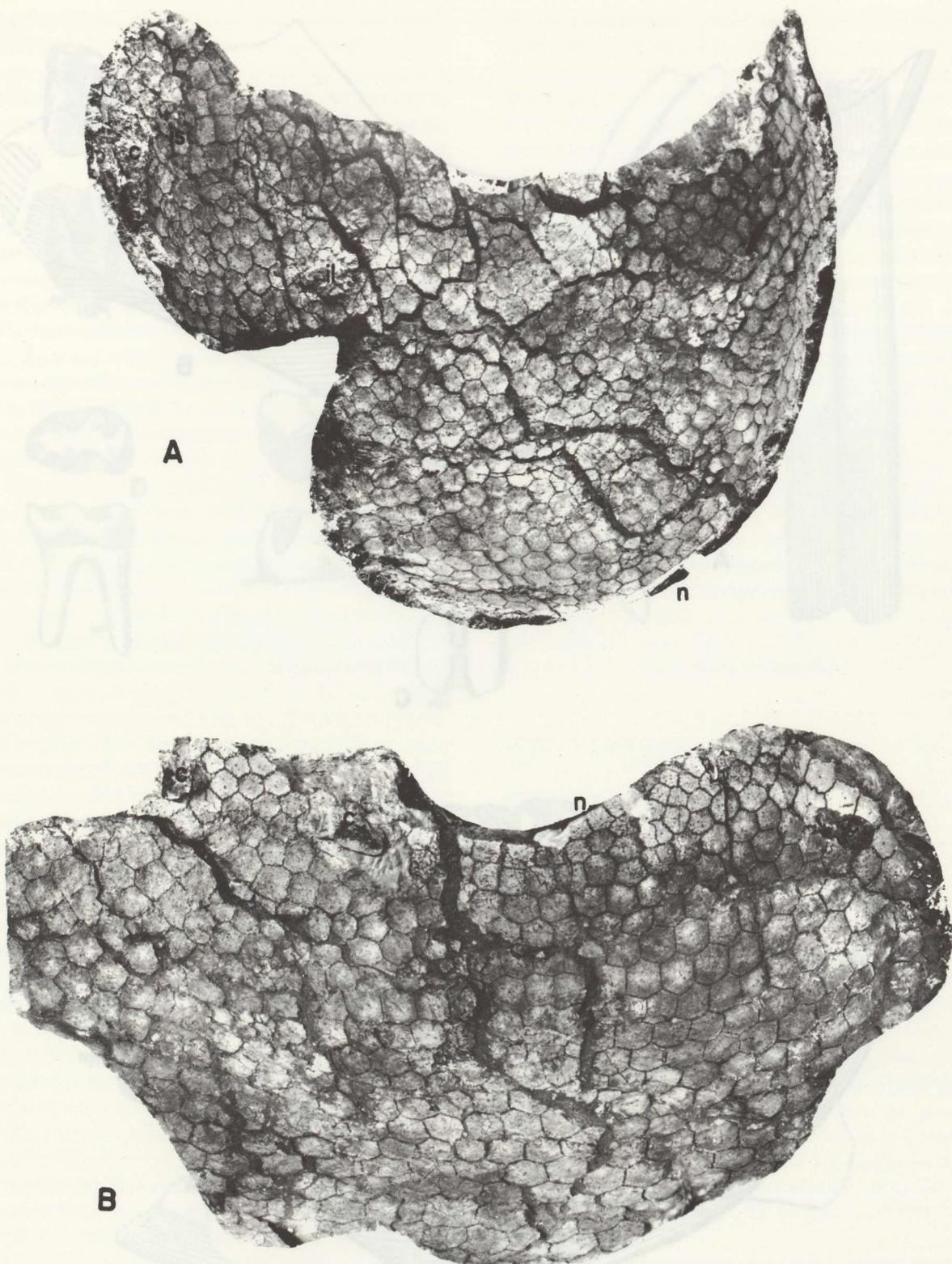


Fig. 9.—A. *Glyptotherium texanum*, partial carapace, TMM 40962-1, internal view (about X 0.12).

B. *Glyptotherium texanum*, partial carapace, TMM 40962-1, internal view of nuchal area (about X 0.17).

c = caliche nodule

il = iliac attachment

is = ischiac attachment

n = nuchal scutes

left mandible of *Geomys* (Nertergeomys) paenebursarius, partial left mandible with incisor and P₄ through M₂, TMM 40857-4, external view (X5).

The drawing shows the external view of the mandible, with the anterior side facing up. The drawing includes a dashed line representing the occlusal surface. The teeth are shaded with different patterns: the incisor is stippled, P₄ has horizontal lines, M₁ has vertical lines, and M₂ has diagonal lines. The label "MSS" is located at the bottom right of the drawing.

The fragmentary mandible shows the anterior side of the dentary bone and the anterior teeth. The anterior teeth are missing. The drawing shows the external view of the mandible, with the anterior side facing up. The teeth are shaded with different patterns: the incisor is stippled, P₄ has horizontal lines, M₁ has vertical lines, and M₂ has diagonal lines. The label "MSS" is located at the bottom right of the drawing.

The fragmentary mandible shows the anterior side of the dentary bone and the anterior teeth. The anterior teeth are missing.

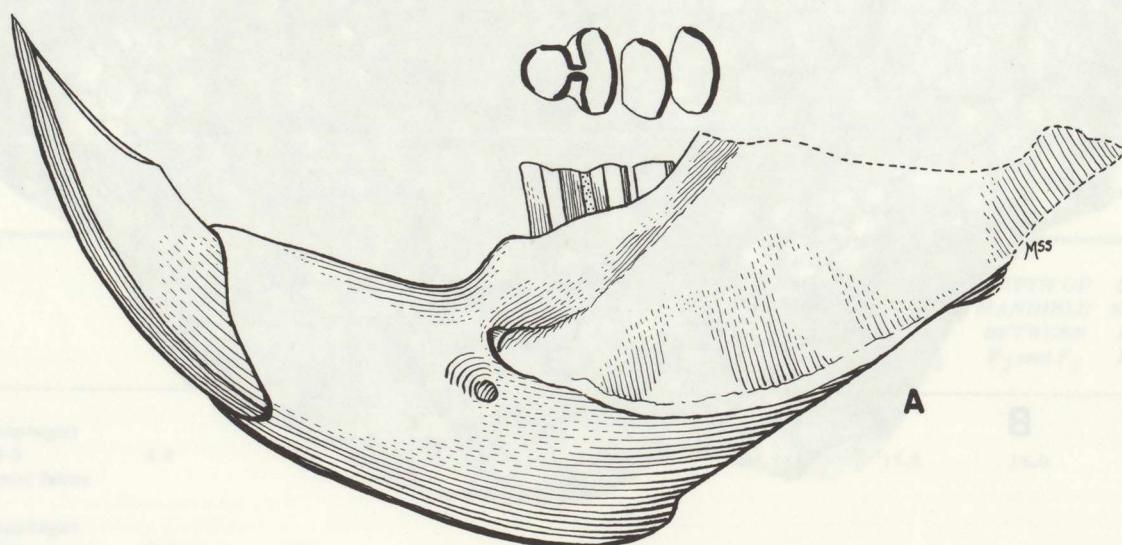
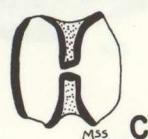
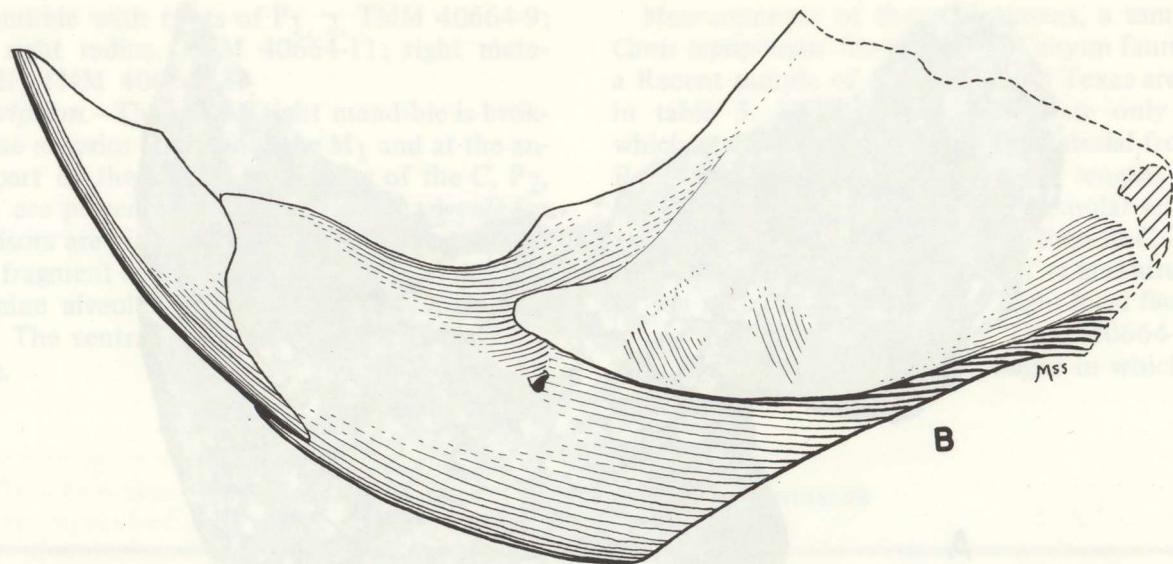


Fig. 10.—A. *Geomys (Nertergeomys) paenebursarius*, partial left mandible with incisor and P₄ through M₂, TMM 40857-4, external and occlusal views (X5).

B. *Geomys (Nertergeomys) paenebursarius*, partial left mandible with incisor, TMM 40857-3, external view (X5).

C. *Geomys (Nertergeomys) paenebursarius*, damaged P₄, TMM 40857-16, occlusal view (X10).

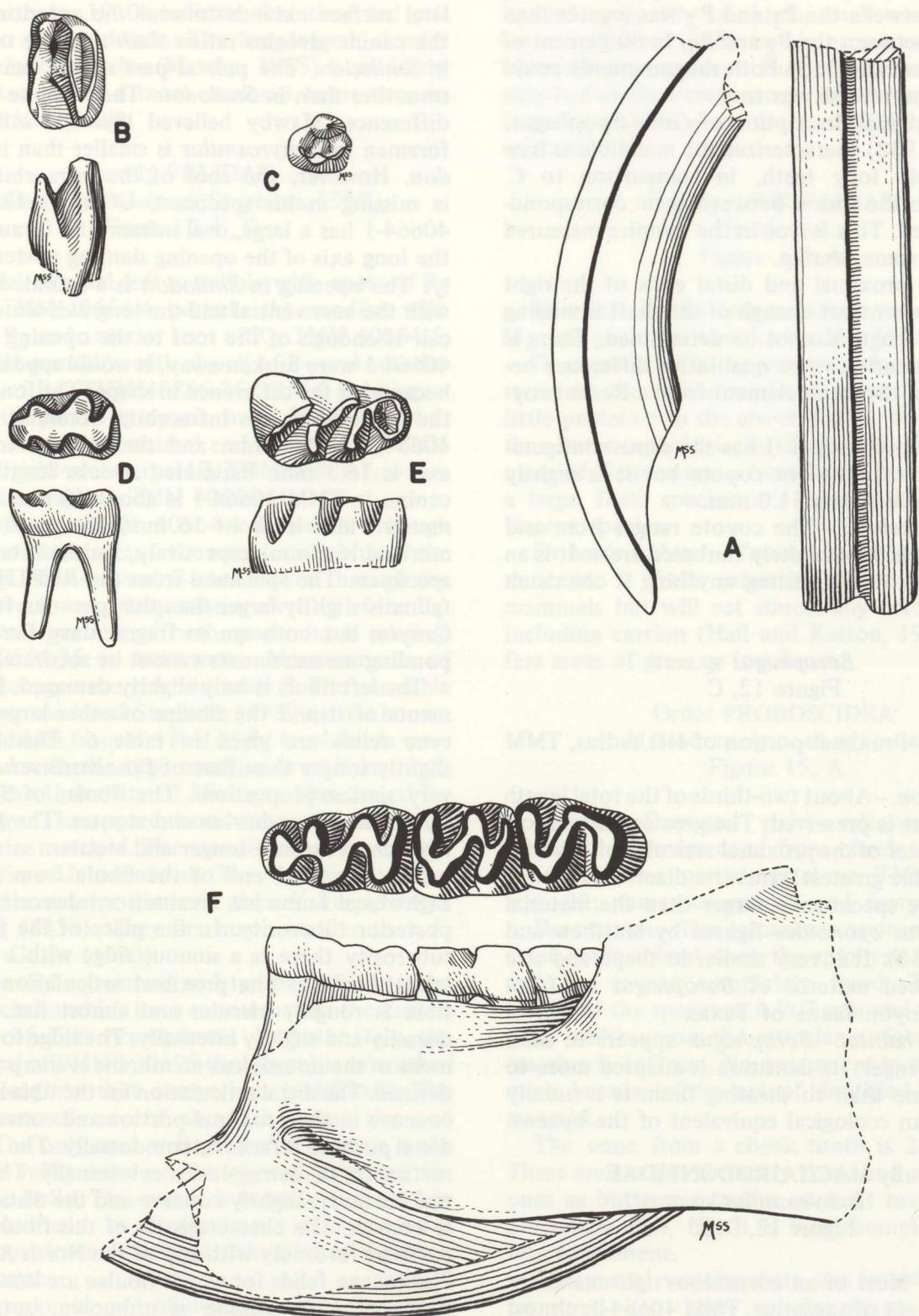


Fig. 11.—A. *Cratogeomys* sp., upper left incisor, TMM 40664-20, external and anterior views (X5).
 B. *Prodipodomys* sp., left M_1 , TMM 40857-13, occlusal and internal views (X10).
 C. *Perognathus* sp., left P^4 , TMM 40857-13, occlusal view (X10).
 D. *Onychomys* sp., left M_1 , TMM 40857-12, occlusal and external views (X10).
 E. *Sigmodon hirsutus*, left M_1 , TMM 40857-11, occlusal and internal views (X10).
 F. *Sigmodon hirsutus*, partial left mandible with partial incisor and M_1 through M_3 , TMM 40857-10, external and occlusal views (X10).

measurements could be taken, the depth of the mandible between the P_1 and P_2 was greater than the depth between the P_2 and P_3 . In 80 percent of the *C. latrans* in which both measurements could be taken, the reverse was true.

In the original description of *Canis lepophagus*, Johnston (1938) characterized the mandible as having relatively long teeth, in comparison to *C. latrans*, with the spaces between them correspondingly reduced. This is true in the samples measured but there is some overlap.

Both the proximal and distal ends of the right radius are present but enough of the shaft is missing so that the length cannot be determined. There is no major quantitative or qualitative difference between it and the same element from a Recent coyote.

The right metacarpal II has the same configuration as that of a Recent coyote but it is slightly smaller. The length is 51.0 mm.

Probable habitat.—The coyote ranges from arid deserts to humid moderately timbered areas. It is an opportunistic feeder, eating anything it can catch or find.

Borophagus sp.
Figure 12, C

Material.—Proximal portion of left radius, TMM 40664-221.

Description.—About two-thirds of the total length of the radius is preserved. The greatest anteroposterior diameter of the proximal articulation is about 19 mm and the greatest transverse diameter is about 26 mm. The specimen is larger than the material of *Osteoborus cyonoides* figured by Matthew and Stirton (1930). It is very similar in shape and size to undescribed material of *Borophagus* sp. from the Cita Canyon fauna of Texas.

Probable habitat.—*Borophagus* appears to have been a scavenger; its dentition is adapted more to crushing bone than to shearing flesh. It is usually considered an ecological equivalent of the hyaena.

Family MACHAIRODONTIDAE
Ischyrosmilus sp.
Figure 12, D, E

Material.—Most of an edentulous right maxillary with a fragment of a palatine, TMM 40664-1; almost complete left fibula, TMM 40856-22.

Description.—Much of the maxillary posterior to the infraorbital canal is missing and the occlusal area is severely damaged. The alveolus for the canine is present but damaged. Only traces of several alveoli posterior to the canine are present. Mawby (1965) described a partial maxillary and premaxillary of *Ischyrosmilus johnstoni* from the Cita Canyon fauna of Randall County, Texas. TMM 40664-1 is similar to his specimen on two points. The suture

between the maxillary and premaxillary on the palatal surface extends to near the anterior edge of the canine alveolus rather than near the middle as in *Smilodon*. The palatal part of the maxillary is smoother than in *Smilodon*. There is one point of difference; Mawby believed that the infraorbital foramen in *Ischyrosmilus* is smaller than in *Smilodon*. However, the roof of the infraorbital canal is missing in his specimen, UCMP 66485. TMM 40664-1 has a large, oval infraorbital foramen with the long axis of the opening slanting posterodorsally. The opening in *Smilodon* is a rounded triangle with the base ventral and the long axis almost vertical. If enough of the roof to the opening in TMM 40664-1 were broken away, it would appear smaller because of the difference in shape. The long axis of the opening to the infraorbital foramen in TMM 40664-1 is 30.0 mm and the greatest transverse axis is 16.3 mm. Estimated alveolar length of the canine in TMM 40664-1 is about 40 mm and estimated width is about 16 mm, compared to 36.5 mm and 16.5 mm, respectively, for the Cita Canyon specimen. The specimen from the Red Light local fauna is slightly larger than the specimen from Cita Canyon but both are so fragmentary that corresponding measurements cannot be accurately made.

The left fibula is only slightly damaged. Measurements of it and the fibulae of other large Pleistocene felids are given in table 6. This fibula is slightly longer than that of *Dinobastis serus* and of very similar proportions. The fibulae of *Smilodon californicus* are shorter and stouter. The fibula of *Felis atrox* is both longer and stouter.

The proximal end of the fibula from the Red Light local fauna has an anterior tuberosity but no posterior tuberosity. In the place of the posterior tuberosity there is a sinuous ridge with a concave lateral surface. The proximal articulation for the tibia is roughly circular and almost flat. It faces dorsally and slightly internally. The ridge for attachment of the interosseous membrane is sharp and well defined. The distal articulation for the tibia is lunate, concave in the proximal portion and convex in the distal portion. It faces internodorsally. The articular surface for the astragalus faces internally. The proximal portion is slightly concave and the distal, slightly convex. The characteristics of this fibula do not compare favorably with any of the North American Pleistocene felids for which fibulae are known. The fibula of *Ischyrosmilus* is unknown, but Mawby (1965) described a right tibia which he referred to *Ischyrosmilus*. It is long and slender. The articulations for the fibula are complementary to the articulations for the tibia of TMM 40856-22 and they are only about 5 mm farther apart. On the bases of proportions and the shape and position of the articular facets, TMM 40856-22 is best referred to *Ischyrosmilus*.

Probable habitat.—The accumulations of proboscidian remains associated with machairodonts

(Evans, 1961) and the specialization of the dentition (Matthew, 1910) indicate that they fed primarily on proboscidians. The long-legged, slender build of *Ischyrosmilus* (Mawby, 1965) is probably an adaptation for a more cursorial habit than in other machairodonts.

Family FELIDAE

Felis cf. rexroadensis Stephens, 1959
Figure 12, F, G

Material.—Partial left mandible with roots of P₃ and P₄, TMM 40664-4; partial right mandible with roots of P₃ and anterior root of P₄, TMM 40664-5; partial left mandible with alveoli of P₃ and anterior alveolus of P₄, TMM 40856-36; partial right squamosal with partial tympanic bulla, TMM 40664-6; severely damaged proximal end of humerus, TMM 40664-8; right metacarpal III, TMM 40664-7; water-worn left astragalus, TMM 40664-18.

Description.—TMM 40664-4 is broken through the canine alveolus and the anterior alveolus of the M₁. TMM 40664-5 and -36 are broken through the canine alveolus and the posterior alveolus of the P₄. The ventral portion of both specimens is missing. TMM 40664-36 is waterworn. Measurements of these specimens are given in table 7. The mandible of *Felis rexroadensis* Stephens (1959) is not known. The mandibles from the Red Light local fauna were compared with the type maxillaries of *F. rexroadensis* in the University of Michigan Museum of Paleontology. The apparent occlusion was very good and the size matched. The mandibles are larger than *Lynx rufus* or *L. canadensis*. They are slightly larger and have a shorter diastema than *F. longignathus* Shotwell (1956). They are much smaller than *F. lacustris* Gazin (1933).

The partial squamosal and tympanic bulla is the only specimen which has a counterpart in the known material of *Felis rexroadensis*. Unfortunately, the squamosal of UMMP 34195 (holotype) is so crushed and incomplete that comparison is difficult. The two squamosals are of about the same size and shape. The only area well preserved in both is the notch or valley between the glenoid fossa and the tympanic bulla. This notch is broadly U-shaped in both specimens. In all specimens of *Lynx rufus* and *L. canadensis* examined, this notch is V-shaped and narrower.

The proximal end of a humerus is larger than that of *Lynx rufus* but it is too severely damaged to be accurately measured.

The right metacarpal III does not differ qualitatively from that of *Lynx rufus* but it is larger. The total length is 31.3 mm.

The left astragalus also does not differ from that of *Lynx rufus* except in being larger. The greatest length is 30 mm and the greatest width is 19 mm.

Probable habitat.—The modern bobcat is a largely nocturnal "stalk and pounce" predator that occu-

pies a wide range of habitats except open grasslands. It feeds primarily on birds, small mammals, and carrion (Davis, 1960) but is occasionally able to kill weak or young deer. *Felis cf. rexroadensis* probably had similar habits except that it may have been large enough to prey more efficiently on larger animals.

Family MUSTELIDAE

Taxidea sp.

Figure 13, A

Material.—Partial left mandible with alveoli for M₂ and posterior alveolus for M₁, TMM 40855-14.

Description.—The specimen is broken just anterior to the posterior alveolus for the M₁ and a little posterior to the alveoli for the M₂. It is larger than but morphologically identical to Recent specimens of *Taxidea taxus* from Texas. It may represent a large, fossil species or a large individual of the Recent species.

Probable habitat.—*Taxidea taxus* is a burrowing mustelid. It feeds primarily on small burrowing mammals but will eat almost any vertebrate flesh including carrion (Hall and Kelson, 1959). It prefers areas of grass or low brush.

Order PROBOSCIDEA

Mastodont, gen. et sp. indet.

Figure 15, A

Material.—Damaged right calcaneum, TMM 40664-27; unworn cone from cheek tooth, TMM 40664-26; two partial vertebrae, TMM 40664-28 and -29; numerous enamel and ivory fragments.

Description.—The calcaneum appears to be from a sub-adult animal since the epiphysis at the proximal end is not completely fused. The greatest length of the specimen is 207 mm and the approximate width across the articular surface for the astragalus is 160 mm. No assignment to taxon can be made because of the lack of identified comparative material.

The cone from a cheek tooth is 28 mm high. There are a major accessory conid and several minor ones as buttresses to the cone. It may be from a *Stegomastodon*, but it is too incomplete for definite assignment.

The partial vertebrae are too incomplete to be measured and have no important qualitative characteristics.

Probable habitat.—Mastodons were probably browsing animals.

Order LAGOMORPHA

Family LEPORIDAE

Two types, gen. et sp. indet

Figure 15, B, C, D

Material.—Upper incisor, type A, TMM 40857-72;

TABLE 6

MEASUREMENTS IN MM OF THE FIBULAE OF *ISCHYROSMILUS*
AND OTHER LARGE PLEISTOCENE FELIDS

	TMM 40856-22 <i>ISCHYROSMILUS</i> <i>RED LIGHT L.F.</i>	DINOBASTIS <i>SERUS</i> (<i>MEADE</i> , 1961)	SMILODON <i>CALIFORNICUS</i> (<i>MERRIAM & STOCK</i> , 1932) <i>CAVE RANCHO LA BREA</i>	FELIS ATROX (<i>MERRIAM & STOCK</i> , 1932) <i>RANCHO LA BREA</i>
Greatest length	317	287	212.7-284.7	369
Greatest ant.-post. diameter proximal end	24.6	25-26	32.5-45.9	35.4
Greatest ant.-post. diameter distal end	28.9	29	17.2-26.7	—
Transverse diameter distal end	15.9	14	14.4-34.0	—
Greatest diameter, middle of shaft	12.9	10.5	9.4-13.7	16.1

upper incisor fragments, type B, TMM 40857-73; partial right mandible with P_4 , TMM 40856-45; left femur, TMM 40855-16; partial sacrum, TMM 40962-2; numerous other skeletal fragments.

Description.—The two types of incisors are differentiated by the presence or absence of folding of the enamel along the groove of the incisor. Type A, TMM 40857-72, has a deep fold in the enamel extending posterior from the external expression of the groove. The enamel in type B, TMM 40857-73, is not folded and simply follows the external expression of the groove. It is not possible at this time to assign these incisors to genera.

The partial mandible is from a small animal, but it might not have been an adult. Only the portion anterior to the M_1 remains. The P_3 , diagnostic in rabbits, is missing. The P_4 is 1.9 mm long and 2.6 mm wide.

The femur is only slightly damaged, mostly from stream abrasion. It is 98 mm long and about 15 mm wide at the distal end.

Only the first two vertebrae are preserved in the sacrum. The greatest width across the pleurapophyses is 17 mm.

Probable habitat.—Rabbits are both grazers and browsers. They inhabit a wide range of environments.

TABLE 7

MEASUREMENTS IN MM OF MANDIBLES OF *FELIS* CF.
REXROADENSIS FROM THE RED LIGHT LOCAL FAUNA

	LENGTH DIASEMA	ALVEOLAR LENGTH P_3	ALVEOLAR LENGTH P_4	DEPTH MANDIBLE UNDER P_3	DEPTH MANDIBLE UNDER P_4
TMM 40664-4	app. 9.4	8.9	11.7	16.8	17.5
TMM 40664-5	app. 9.0	9.7	—	—	—
TMM 40856-36	—	8.7	—	—	—

Order ARTIODACTYLA
Family TAYASSUIDAE
Platygonus bicalcaratus Cope, 1893
Figure 13, B, C

Material.—Left M¹, TMM 40664-17; right C¹, TMM 40856-23; partial right C¹, TMM 40664-58; left mandible fragment with roots of P₂₋₃, TMM 40859-1; partial proximal end of right radius-ulna, TMM 40664-15; distal epiphysis of left radius-ulna, TMM 40856-32; left astragalus, TMM 40855-9.

Description.—The left M¹ is worn to the level of the cingulum anteriorly and almost so, posteriorly. The cusps are worn almost flat. The cingulum is continuous except where it merges with the lingual sides of the internal cusps. Greatest anteroposterior diameter is 17.1 mm and the greatest transverse diameter is 15.3 mm. This tooth is exactly like the left M¹ in TMM 31175-12 from the Blanco fauna except that the posterior portion of the cingulum in the latter has been destroyed by crowding with the M². TMM 31175-12 was referred to *Platygonus bicalcaratus* by Meade (1945).

The complete upper right canine, TMM 40856-23, is 114 mm in length, 25.2 mm in greatest antero-posterior diameter, and 17.0 mm in greatest transverse diameter. The anterior wear facet is about 40 mm long and there is a small posterior wear facet 8 mm long. Except for degree of wear, this tooth is identical to the right upper canine of TMM 31175-12.

The partial upper right canine is so extensively damaged that no accurate measurements can be made, but it is slightly smaller.

The left mandible fragment is broken at the anterior alveolus of the P₄ and about 10 mm anterior to the alveoli of the P₂. It compares favorably with several mandibles of *Platygonus bicalcaratus* from the Blanco fauna. The alveolar length of the P₂ is 8.6 mm. and of the P₃, 9.7 mm.

The olecranon process is missing from the proximal end of the fused right radius-ulna. This specimen is slightly larger and the posterior side is more concave than in material from Laubach Cave, Georgetown, Texas, which has been referred to *Platygonus compressus* by Slaughter (1966). The proximal articulation of the radius is 33.3 mm wide and 16 mm deep.

The distal epiphysis of the left radius-ulna resembles that of *Platygonus compressus* in shape and size. It is 37 mm wide and 25 mm deep.

The left astragalus is almost identical to a specimen of *Platygonus compressus*, also from Laubach Cave. Length along the outer side is 39.2 mm and the width of the distal end is 24 mm.

The postcranial material is referred to *Platygonus bicalcaratus* because of its resemblance to *P. compressus* and on the assumption that only one species of peccary is present in the Red Light local fauna.

Discussion.—Hibbard and Riggs (1949) placed

Platygonus texanus Gidley (1903) in synonymy with *Platygonus bicalcaratus* Cope (1893). The series of specimens that they described from the Keefe Canyon Rexroad fauna contained material which could be assigned to each species, but there were also specimens which were intermediate in character. The material in the TMM collections from the Blanco fauna was divided into the two species by Meade (1945). A re-examination of the Blanco material does not support the presence of two clearly differentiated species of *Platygonus* in the Blanco fauna.

Probable habitat.—The Recent javalina is primarily herbivorous and inhabits brushy country. *Platygonus bicalcaratus* may have preferred a more open habitat, as shown by some of the fossil assemblages in which it has been found.

Family CAMELIDAE
Tanupolama sp.
Figure 13, D, E

Material.—Partial left scapula, TMM 40855-7; partial left radius-ulna, TMM 40664-12; distal articulation of right radius-ulna, TMM 40855-11; right unciform, TMM 40664-218; partial left tibia, TMM 40664-274; right calcaneum, TMM 40664-16.

Description.—The partial scapula is extensively damaged; only about 10 cm of the distal portion remains. The acromion process, the medial coracoid tuberosity, and both lateral sides of the glenoid cavity are missing. The anteroposterior diameter of the glenoid cavity is 38.0 mm compared to 37.5 mm in a Recent specimen of *Lama*. The preserved portions of the dorsal and ventral margins of the scapula are almost straight and thick. In *Lama*, these margins are very concave and thin.

The partial radius-ulna lacks the distal one-half and the olecranon process. It is slightly larger than the same element of a Recent *Lama*. The greatest width of the proximal articular surface of the radius is 42.3 mm; in *Lama* it is 41.8 mm. The only qualitative difference between the fossil specimen and *Lama* is that the fossil specimen has a foramen just distal to the lateral tuberosity.

The distal articulation of a right radius-ulna is very similar to that of *Lama* except that it is larger. The maximum width of the articulation is 52 mm compared to 43 mm for *Lama* and 63 mm for *Tanupolama blancoensis* (Hibbard and Riggs, 1949). This specimen appears to be too large to fit with the other material of *Tanupolama* sp. and too small to be assigned to *Tanupolama blancoensis*. It is included with the smaller *Tanupolama* specimens for lack of further evidence regarding its taxonomic position.

The right unciform differs from that of *Lama* in having a longer posteroventral process and in being slightly larger.

About 5 cm is missing from the proximal end of

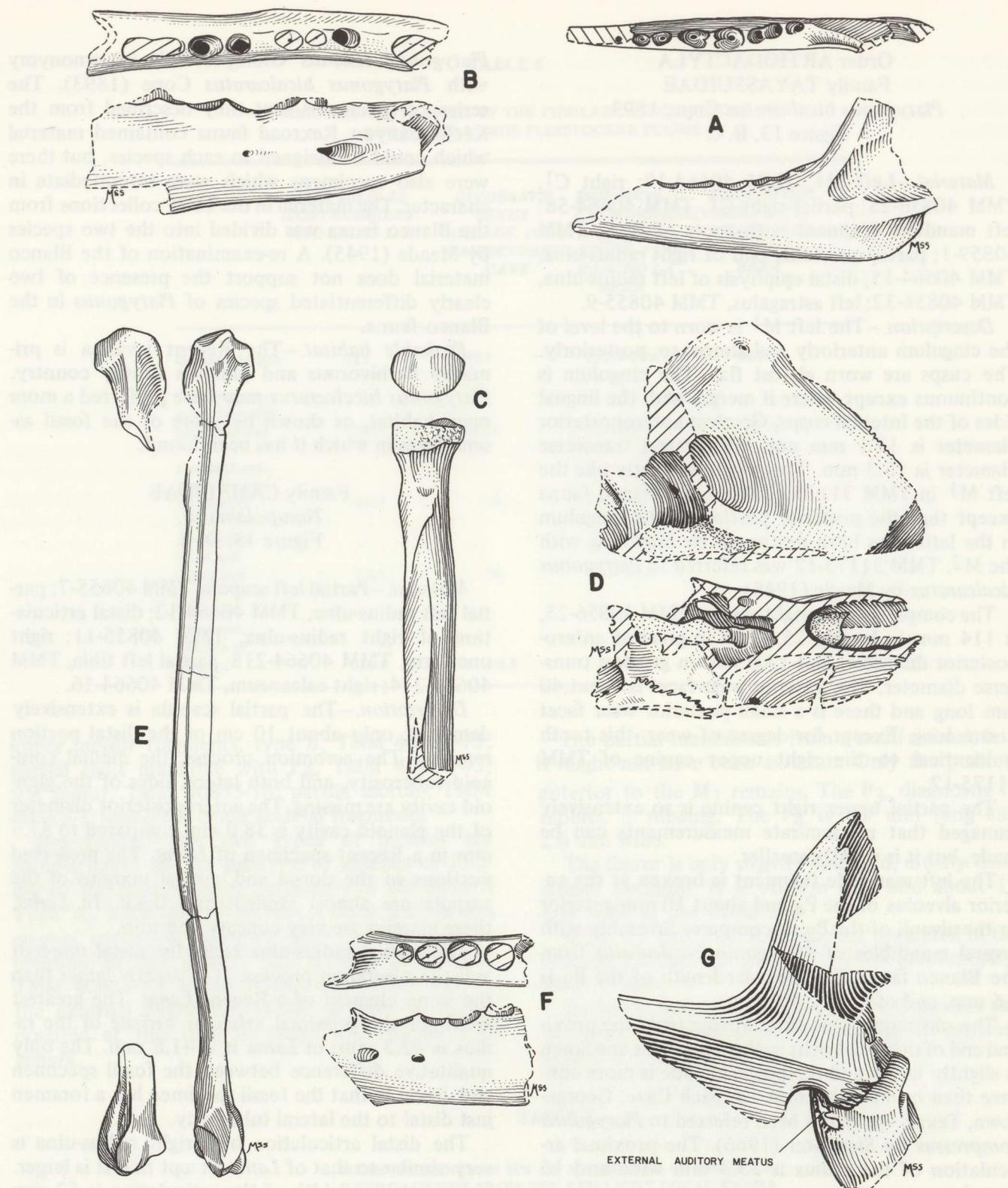


Fig. 12.—A. *Urocyon cf. progressus*, partial left mandible with alveoli of P₄ through M₃, TMM 40855-15, occlusal and external views (X1).

B. *Canis cf. lepophagus*, partial right mandible with alveoli or roots of C through P₄, TMM 40664-3, occlusal and external views (X1).

C. *Borophagus sp.*, proximal portion of left radius, TMM 40664-221, anterior and proximal views (X½).

D. *Ischyrosmilus sp.*, partial right maxillary, TMM 40664-1, external and occlusal views (X½).

E. *Ischyrosmilus sp.*, left fibula, TMM 40856-22, complete internal view and external views of distal and proximal ends (X½).

F. *Felis cf. rexroadensis*, partial left mandible with roots of P₃ and P₄, TMM 40664-4, occlusal and external views (X1).

G. *Felis cf. rexroadensis*, partial right squamosal with partial tympanic bulla, TMM 40664-6, posterior view showing shape of notch between glenoid fossa and tympanic bulla (X2).

About 5 cm is missing from the proximal end of the tibia. The shaft is crushed anteroposteriorly to within 8 cm of the distal end. The distal articulation was extensively weathered before burial. The distal articulation has an anteroposterior diameter of 25.3 mm and a greatest width of 37.7 mm. The same measurements for a specimen of *Lama* are 28.5 mm and 41.3 mm, respectively. The measurements of the fossil specimen would have been slightly larger had it not been weathered. The estimated total length of the specimen is 370 mm, the same measurement in *Lama* is 270 mm.

The calcaneum is 92.7 mm long, the greatest width through the sustentaculum is 28.0 mm and the greatest anteroposterior diameter through the fibular surface is 39.1 mm. The same measurements for a specimen of *Lama* are 84.6 mm, 24.7 mm, and 37 mm, respectively. There are a few minor differences between the articular surfaces of the fossil calcaneum and that of *Lama*. However, the most striking difference is that, in comparison to *Lama*, the body of the fossil calcaneum is tilted about 20° posterior relative to the articular area.

With the possible exception of TMM 40855-11, the material described above is from a small *Tanupolama* similar to the Recent *Lama* but with longer limbs.

Tanupolama mirifica Simpson (1929), *T. longurio* (Hay) (1921), *T. blancoensis* Meade (1945), and *T. seymourensis* Hibbard and Dalquest (1961) are much larger animals. The smaller, well described species of *Tanupolama* are *T. macrocephala* (Cope) (1893) and *T. vera* (Matthew) (1909) if one follows Hibbard and Dalquest (1962) in synonymizing *T. americanus* (Wortman) (1898) and *T. stevensi* (Merriam and Stock) (1925) with *T. macrocephala*. Both *T. macrocephala* and *T. vera* are slightly larger than *Lama*. The material from the Red Light local fauna may belong to either of these or to a new species.

Probable habitat.—Skeletal material and dentitions indicate that the smaller species of *Tanupolama* were probably browsers in relatively brushy country.

Tanupolama cf. *blancoensis* Meade, 1945

Figure 13, F

Material.—Three first phalanges, TMM 40856-14, 40664-222, and 40664-226.

Description.—The three first phalanges have lengths of 117 mm, 129 mm, and 123 mm respectively. All are very slender. Hibbard and Riggs (1949) recorded lengths of 127 mm and 130 mm for anterior first phalanges and 113 mm for a posterior first phalange of a specimen of *Tanupolama blancoensis* from the Blanco fauna (AM 20085). First phalanges from the Rexroad fauna assigned to this species by Hibbard and Riggs (1949) were from 84 mm to 108 mm long. All of this material assigned

to *T. blancoensis* is also very slender. The specimens from the Red Light local fauna are similar to the material described by Hibbard and Riggs and to phalanges referable to *T. blancoensis* in the TMM Blanco fauna collections.

Probable habitat.—This long-limbed species was probably a browser with habitat requirements similar to those of the Recent African giraffes.

Undescribed Long-limbed Camel (=*Leptylopus percelsus* Matthew, Meade 1945)

Figure 14, A

Material.—Partial left radius-ulna, TMM 40664-25.

Description.—The olecranon process and the distal portion of the specimen are missing. There is a prominent rugosity proximal and slightly anterior to the proximal interosseous foramen. This rugosity is elongated parallel to the long axis of the bone. Anterior to this rugosity there is a sharp groove. The bicipital rugosity is longer than wide and has a deep depression in the proximal portion. The lateral tuberosity is well developed.

All of the radii-ulnae of *Titanotylopus* (=*Gigantocamelus*), *Camelops*, *Tanupolama*, and *Camelus* examined have no sign of a rugosity in the area of the proximal interosseous foramen and have a more rounded bicipital rugosity with little or no depression. *Lama* has a small roughened area in a depression proximal to the proximal interosseous foramen and a bicipital rugosity more similar to that of TMM 40664-25. However, the bicipital rugosity is not as oval and the depression is relatively shallower and smaller.

The unusually long radius-ulna from the Blanco fauna, TMM 31179-28, referred to *Leptylopus percelsus* Matthew by Meade (1945) does have these distinctive characters and is of similar size. Unfortunately, the total length of the specimen from the Red Light local fauna cannot be determined. Comparative measurements of these two specimens are given in table 8. The two specimens are so much alike and so different from the other Pleistocene camels studied, that they must belong to at least the same genus.

The same characters used to separate these long-limbed camels from the other Pleistocene camels are present in a specimen, TMM 31132-18, from Lapara Creek fauna (Early Clarendonian). This specimen is referred to *Procamelus occidentalis* by Patton (1969). There are also some other similarities between this specimen and the radius-ulna from the Blanco fauna. This may have a bearing on the ancestry of these long-limbed camels or indicate that these characters are primitive.

Discussion.—The taxonomy of the specimens which Meade (1945) referred to *Leptylopus percelsus* Matthew has had a history of confusion and nomenclatural error.

TABLE 8

MEASUREMENTS IN MM ON RADII-ULNAE OF LONG-LIMBED
CAMELS (= *LEPTOTYLOPUS PERCELSUS*)

	WIDTH, PROX. END OF RADIUS	WIDTH AT ANT. OF PROX. INTER- OSSEUS FORAMEN	DEPTH AT ANT. OF PROX. INTER- OSSEUS FORAMEN
TMM 31179-28 "Leptylopus <i>percelus</i> " Blanco fauna	app. 85	62	59
TMM 40664-25 Red Light l.f.	79	57	57

Matthew had referred, in an unpublished manuscript, to a long-legged camel from the Blanco Beds. He called it *Leptylopus* and compared it to *Alticamelus*. He neither described it nor gave it a specific name.

Meade (1945) was informed that a skeleton, AM 20085, of a long-legged camel from the Blanco fauna in the American Museum collections, was labeled "*Leptylopus percelus*" Type in the handwriting of Matthew. He then referred the material which he had to this unpublished name without examining the specimen to which this name had been applied.

Hibbard and Riggs (1949) investigated AM 20085 and determined that it belonged to the taxon *Tanuropalma blancoensis* Meade 1945, which was described in the same publication that the name "*Leptylopus percelus*" was used.

Webb (1965), on the basis of Meade's published measurements, considered this long limb material to be from an unusually long-legged *Titanotylopus*. There is no similarity, either quantitative or qualitative, between "*Leptylopus*" and *Titanotylopus*.

This long-limbed camel now has no name since "*Leptylopus percelus*" is clearly a *nomen nudem*. It would be very desirable to describe and name this unusual camel if only a dentition could be referred to the limb material. Since this cannot be done and the possibility exists that a dentition belonging to this camel may already be described, I have decided not to add more possible confusion to the present situation by giving a name to this animal.

Probable habitat.—The long, slender limbs of this camel show that it probably was a giraffe-like animal. It probably browsed on high brush or small trees as does the Recent giraffe.

Camelops sp.
Figure 13, G

Material.—Left mandible fragment with P₄, TMM

40664-14; partial tibia, TMM 40856-97; left calcaneum, TMM 40856-109; right astragalus, TMM 40664-216; cervical vertebra, TMM 40664-293.

Description.—The left mandible fragment is broken just posterior to the P₄ and 120 mm anterior to the P₄. Both breaks occurred prior to burial. The anterior break runs posteriorly from the dorsal edge of the mandible and appears to have followed the posterior edge of the symphysis. The distance from the anterior edge of the P₄ to the posterior part of the symphysis is estimated as 75 mm. The mandible is 63 mm deep under the anterior part of the P₄. The diastemal crest is sharp and convex lingually. The P₄ has a crown height of 33 mm, an occlusal length of 33.1 mm, and a maximum occlusal width of 14.4 mm. The length and width at the base of the tooth are 30.3 mm and 15.4 mm respectively. The anterior portion of a small enamel lake is present in the posterior part of the tooth. The rest of this enamel lake is broken out. A wear facet from the M₁ is present on the posterior surface of the tooth. The morphology of the P₄ does not differ significantly from that of most *Camelops* and is less complex than that of *Titanotylopus* (= *Gigantocamelus*). Tooth morphology, large size, and absence of a P₃ are the bases for assignment of this specimen to *Camelops*. Comparative measurements for this specimen and the two largest species of *Camelops*, *C. huerfanensis* (Cragin) (1892) and *C. hesternus* (Leidy) (1873), are given in table 9. TMM 40664-14 is considerably larger than either. It may represent an unusually large specimen of either or an undescribed species.

The partial tibia is too damaged to provide accurate measurements or comparisons, but it is from a large camel.

The left calcaneum is slightly damaged. The greatest length is 182 mm and the maximum anteroposterior diameter is 86 mm. Corresponding measurements for thirteen calcanea of *Camelops hesternus* reported by Webb (1965) had observed

ranges of 157 to 170 mm and 65 to 76.7 mm, respectively. There are several differences between this specimen and calcanea of *Titanotylopus spatulatus* from the Blanco fauna. The fibular surface is much narrower, the posterior edge of the body of the calcaneum is less expanded, the curved distal astragalar facet has a larger posterior portion, and the fossa proximal to this facet is shallower in TMM 40856-109 than in *Titanotylopus*. The morphology of TMM 40856-109 is very similar to that of calcanea from the Ingleside fauna, Texas, referred to *Camelops* by Lundelius (in manuscript).

The right astragalus is slightly waterworn. The length along the external side is 94 mm and the width of the distal end is 61 mm. Eighteen astragali of *Camelops hesternus* reported by Webb (1965) had observed ranges of 80.5 to 91.9 mm and 55.3 to 64.6 mm for corresponding measurements. The major difference between TMM 40664-216 and astragali of *Titanotylopus* from the Blanco fauna is that, in the former, there is no separation of the sustentacular and parasustentacular facets; in the latter, these two facets are completely separated by a low, well defined trough. *Camelops* astragali from the Ingleside fauna do not have these facets separated. In Webb's (1965) figures of a *Camelops hesternus* astragalus, there appears to be a partial separation of these facets.

The cervical vertebra lacks the central portion of the neural arch, and other parts of the specimen are damaged. It is probably a third or fourth cervical vertebra because of the relatively long hypapophyses and moderately developed costellar processes (Webb, 1965). The length of the centrum is 230 mm. The maximum length listed by Webb for a centrum of a corresponding vertebra from *Camelops hesternus* is 218 mm.

Probable habitat.—*Camelops* appears to have been an open-country form. Webb (1965) believed that it was adapted to grazing but occasionally browsed. I believe that the known species were primarily browsers because of the thin, procumbent incisors which are typical of browsing artiodactyls.

Other Camel Material

Vertebrae, some limb material, and tooth fragments could not be reliably assigned to any of the taxa of camels described in this paper. Some of this material seems to indicate the presence of additional taxa of camels in the Red Light local fauna.

Family CERVIDAE *Odocoileus?* sp. Figure 13, H

Material.—Antler tine, TMM 40856-48.

Description.—The tine is slightly sinuous and moderately compressed. The length is 51.7 mm,

maximum diameter at base is 19.7 mm, and minimum diameter at base is 9.2 mm. The specimen is most likely from a deer, but it may be from some other cervid.

Probable habitat.—This specimen probably represents another browsing herbivore.

Family ANTILOCAPRIDAE *Capromeryx?* sp. Figure 13, I

Material.—Distal end of left humerus, TMM 40855-21.

Description.—The posterior portion of the articular area is damaged. The shape of the remainder of the articular area does not differ from that of a Recent *Antilocapra* but the specimen is only about two-thirds as large. The greatest width across the articulation is 24.6 mm. The tentative assignment to *Capromeryx* is based on the small size of the specimen.

Probable habitat.—*Antilocapra*, the living representative of the family, is an inhabitant of the open plains and is the fastest running North American artiodactyl. The food consists mainly of browse and forbs with minor amounts of grass (Davis, 1960). The habitat of the smaller, fossil antilocaprids may have been somewhat different.

Order PERISSODACTYLA Family EQUIDAE *Equus* aff. *scotti* Gidley, 1900 Figures 15, E, F, G; 16, A, B

Material.—Partial left maxillary with alveolus for P₁, DP₂₋₄, erupting M₁, and unerupted M₂, sectioned to show adult dentition, TMM 40664-23; right P₃, TMM 40664-20; associated partial right M₁, M₂, and fragments of M₃, TMM 40664-255; right M₃, TMM 40664-195; left M₃ in maxillary fragment, TMM 40664-21; right P₃ or P₄, TMM 40856-39; partial left radius-ulna, TMM 40856-52; partial left astragalus, TMM 40664-52; right metacarpal III, TMM 40856-51; left metacarpal III, TMM 40664-292; proximal portion of right metacarpal III, TMM 40891-2; distal portion of metapodial III, TMM 40856-95; three first phalanges, TMM 40664-37, 40891-1, and 40856-1; three second phalanges, TMM 40856-4 and -108, and 40664-3.

Description.—Little remains of the maxillary, TMM 40664-23, except for the bone immediately surrounding the teeth. The bone and the teeth have been fractured and distorted by calicheification. The deciduous teeth are virtually complete and moderately worn. A piece of the anteroexternal portion of the DP₂ is missing. The fossettes of the deciduous teeth are large and complicated with well developed plications except for the pli hypostyle on the DP₂. The pli caballin is well developed on all three. The protocone is small and oval on the DP₂.

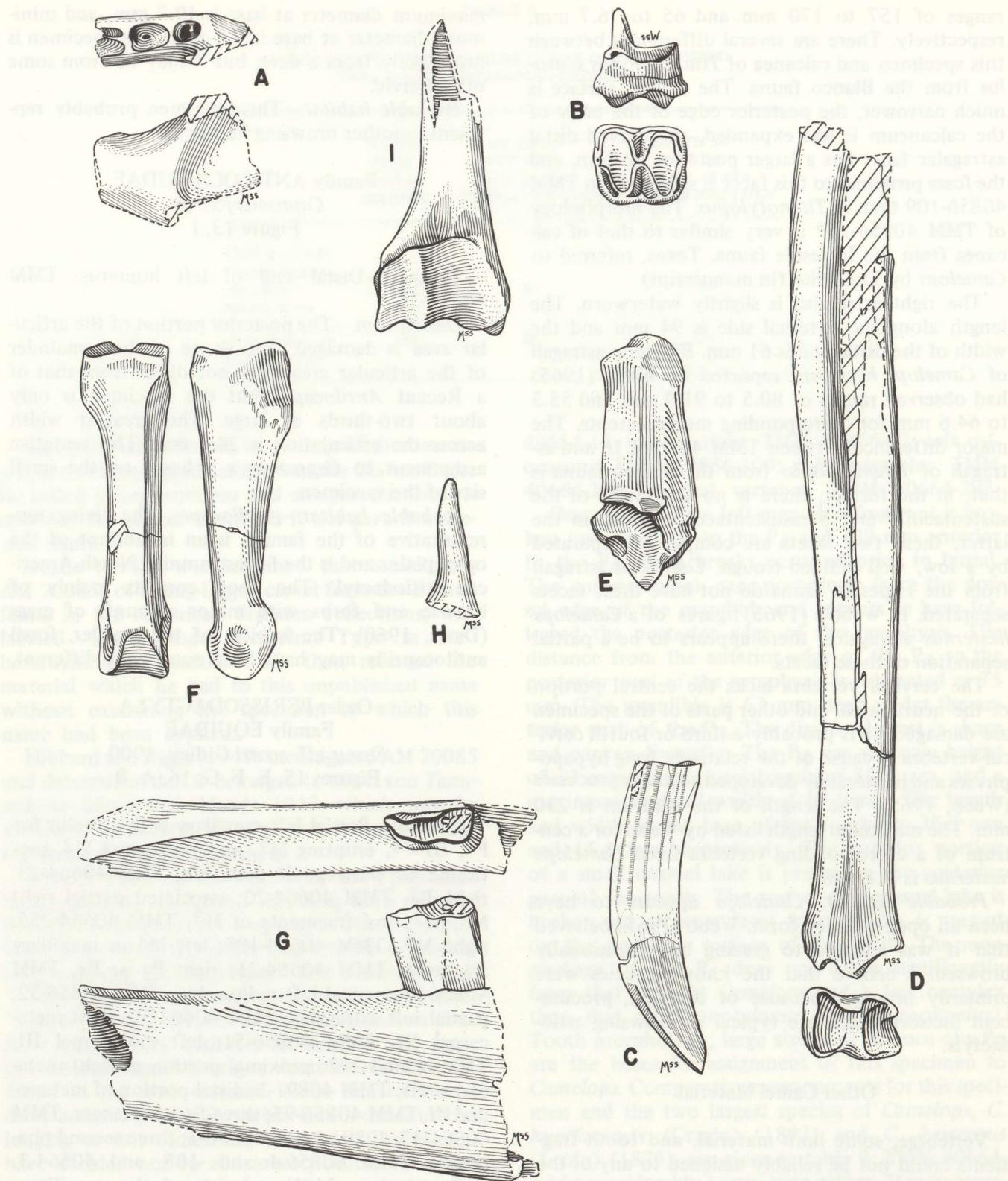


Fig. 13.—A. *Taxidea* sp., partial left mandible with alveoli for M_2 and posterior alveolus for M_1 , TMM 40855-14, occlusal and external views (X1).

- B. *Platygonus bicalcaratus*, left M_1 , TMM 40664-17, occlusal and external views (X1).
- C. *Platygonus bicalcaratus*, right upper canine, TMM 40856-23, internal view (X½).
- D. *Tanupolama* sp., partial left tibia, TMM 40664-274, anterior and distal views (X½).
- E. *Tanupolama* sp., right calcaneum, TMM 40664-16, internal view (X½).
- F. *Tanupolama* cf. *blancoensis*, first phalange, TMM 40664-226, anterior and internal views (X½).
- G. *Camelops* sp., left mandible fragment with P_4 , TMM 40664-14, occlusal and external views (X½).
- H. *Odocoileus?* sp., antler tine, TMM 40856-48, side view (X½).
- I. *Capromeryx?* sp., distal end of left humerus, TMM 40855-21, anterior view (X1).

TABLE 9
MEASUREMENTS IN MM OF MANDIBLES OF *CAMELOPS*

	MANDIBLE DEPTH UNDER <i>P₄</i>	LENGTH <i>P₄</i>	WIDTH <i>P₄</i>	CROWN HEIGHT <i>P₄</i>
<i>Camelops</i> sp.				
TMM 40664-14	63	33.1 (occl.) 30.3 (base)	14.4 (occl.) 15.4 (base)	33
Red Light local fauna				
<i>C. huerfanensis</i> (type)				
USNM 7819, from Hay (1913)	—	27	15	30
Huerfano				
<i>C. huerfanensis</i>				
USNM 5315, from Hay (1913)	—	23	14	25
Minidoka				
<i>C. hesternus</i> , 5 spec.				
from Webb (1965)	53-65	17.4-27.5	10.2-14.7	—
Rancho la Brea				

TABLE 10

MEASUREMENTS IN MM OF DECIDUOUS DENTITIONS
OF VARIOUS SPECIES OF *EQUUS*

	TOTAL	DP ²			DP ³			DP ⁴		
		LENGTH	WIDTH	LENGTH PROTOCONE	LENGTH	WIDTH	LENGTH PROTOCONE	LENGTH	WIDTH	LENGTH PROTOCONE
TMM 40664-23										
<i>E. aff. scotti</i>										
Red Light l.f.	113	43.5	23.5	8.2	34.0	27.0	10.0	35.0	27.8	11.8
UMMP V46404										
<i>E. scotti</i>										
Gilliland l.f.		43.3	23.0	7.8	32.0	23.7	8.9			
UMMP V46820										
<i>E. scotti</i>										
Gilliland l.f.					30.8	23.1	9.4	33.3	21.9	10.5
<i>E. (P.) francescana</i>										
from Schultz (1936)										
Coso Mountains			22.4		33	21.6		34	22.6	
<i>E. (P.) shoshonensis</i>										
from Gazin (1936)										
Hagerman l.f.	118				35	25				

and DP³ and slightly longer on the DP⁴. All three protocones have slight lingual indentations. All enamel ridges have a slight degree of minor crenulation superimposed on the major pattern. The M¹ and M² are newly erupted with only slight wear on the M¹ and none on the M². Table 10 gives the measurements of these deciduous teeth and a few from the Gilliland local fauna of Texas which are assignable to *Equus scotti*. The major differences between the material from these two faunas is that

the Gilliland specimens have a greater lingual indentation of the protocones and the DP³ and DP⁴ are narrower than in the Red Light specimen.

Since the bases of the permanent teeth were visible on the dorsal side of the specimen, it was sectioned to obtain the adult molar pattern. The section is cut rather high and the tooth pattern is that of an early wear stage, particularly in the premolars. It was impractical to section the specimen deeper because of the fracturing by caliche and the incom-

plete development of dentine and cement. As it is, the occlusal surface of the M² was considerably damaged and all teeth were slightly damaged by sectioning. The teeth are large and have long, lingually indented protocones extending well anterior to the comissure in all but the P². The fossettes are large and complicated and usually have well developed plications. The right P³, TMM 40664-20, is only slightly worn and was also sectioned, about 15 mm below the crown. It is essentially the same as the teeth described above.

Measurements of the above teeth and other adult teeth from the Red Light local fauna assigned to *Equus* aff. *scotti* are given in table 11 along with teeth assigned to *E. scotti* by Hibbard and Dalquest (1966) from the Gilliland local fauna of Texas. The enamel configuration of both is very similar. The only apparent qualitative difference is that the Gilliland specimens have, on the average, slightly more complicated fossettes. The only significant difference in measurements is that the Gilliland specimens have longer protocones except in the P² and P³. The difference in length of the P² is due to TMM 40664-23 being sectioned above the point where the anterior region of the P² has developed its greatest length.

The limb material is assigned to this species solely on the basis that it is too large to be assigned to the other two species of *Equus* recognized in the fauna.

The proximal articulation of the radius and part of the shaft are missing from the left radius-ulna. Gazin (1936) lists widths of 60 to 66 mm for the distal articulation of the radius-ulna in five specimens of *Equus (Plesippus) shoshonensis* and 64 mm in one specimen of *E. (P.) simplicidens*. The distal articulation of TMM 40856-52 is not complete but it would have been about 80 mm wide. The greatest width of the sigmoid articular surface of the ulna is 47 mm. The anaconaeus process is very rugose, more so than in any other Pleistocene or Recent *Equus* studied.

Only the inner portion of the left astragalus is preserved. It is 69 mm long. Measurements given by Gazin (1936) for the lengths of the inner sides of five astragali from *Equus (Plesippus) shoshonensis* are from 58 to 63 mm and for two astragali from *E. (P.) simplicidens*, 60 and 60.5 mm.

Measurements of the two complete and one partial metacarpals III are given in table 12 with comparative measurements for other species of *Equus*. The distal portion of a metapodial III,

TABLE 11

MEASUREMENTS IN MM OF PERMANENT DENTITIONS
OF *EQUUS SCOTTI* AND *E. AFF. SCOTTI*

<i>TMM 40664-23</i> <i>E. aff. scotti</i> <i>RED LIGHT L.F.</i>	<i>TMM 40664-20</i> <i>E. aff. scotti</i> <i>RED LIGHT L. F.</i>	<i>TMM 40664-195</i> <i>E. aff. scotti</i> <i>RED LIGHT L.F.</i>	<i>TMM 40664-21</i> <i>E. aff. scotti</i> <i>RED LIGHT L. F.</i>	<i>UMMP V46898</i> <i>E. scotti</i> <i>GILLILAND L.F.</i>	<i>UMMP V42885</i> <i>E. scotti</i> <i>GILLILAND L.F.</i>
P ² Length Width Length Proto- cone	38.8 26.4 11.0	34.0 32.8 13.5		42.1 27.2 10.6	43.0 28.4 12.8
P ³ Length Width Length Proto- cone	33.2 29.5 16.2	32.8 32.8 13.5		32.8 29.8 13.8	31.2 30.4 17.7
P ⁴ Length Width Length Proto- cone	31.9 28.8 15.7			31.8 30.2 16.1	31.0 29.5 18.9
M ¹ Length Width Length Proto- cone	27.6 28.8 13.0			28.1 29.0 14.8	25.7 28.9 15.3
M ² Length Width Length Proto- cone	28.8 28.2 14.6			30.1 27.9 16.2	27.1 27.5 17.3
M ³ Length Width Length Proto- cone		31 25 14.2	30.0 23.3 13.4	30.3 23.6 16.4	13.5 24.4 18.3

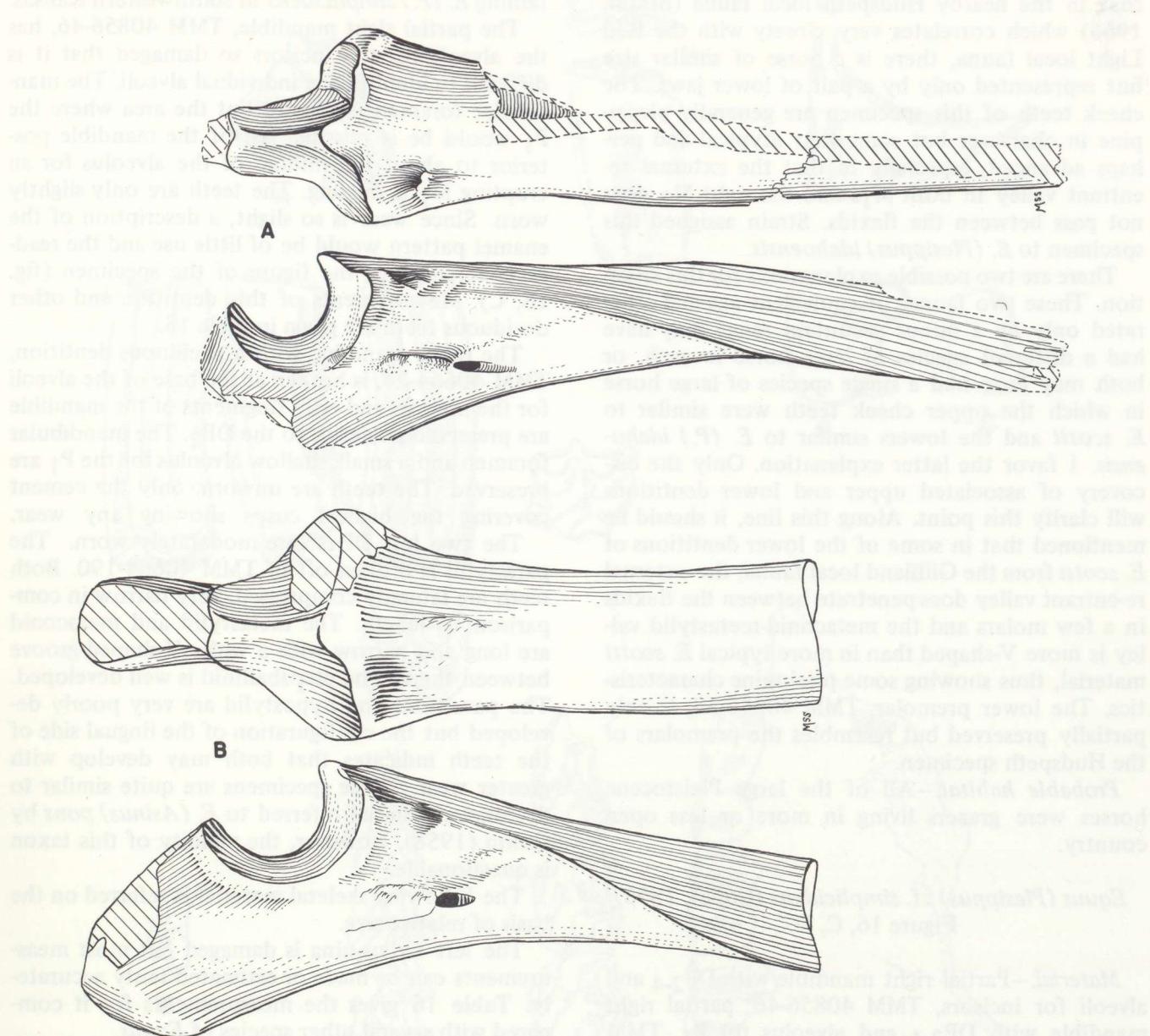


Fig. 14.—A. Unnamed long-limbed camel, proximal portion of left radius-ulna, TMM 40664-25, anterior and internal views (X 1/3).

B. Unnamed long-limbed camel (=*Leptotylopus percelsus* Matthew, Meade, 1945) from the Blanco fauna, proximal portion of left radius-ulna, TMM 31179-28, anterior and internal views (X 1/3).

TMM 40856-95, has a width across the distal articulation of 53.3 mm and a depth across the keel of the distal articulation of 37.0 mm.

Measurements of the three first phalanges are given in table 14, and of the three second phalanges, in table 13.

Comparison of the foot elements from the Red Light local fauna with those of the Gilliland local fauna shows that the primary difference between them is that the metacarpals III from the former are significantly longer.

Assignment of the *Equus* material to species was accomplished in the following manner. Teeth and skeletal material were each divided into apparently

natural groupings. Since three groups were found in both the teeth and the skeletal material, these were correlated on the basis of size. Then, comparisons were made with described material. Because there was no associated material, assignment of skeletal elements may be partially in error.

Discussion.—This is the first report of the presence of an *Equus scotti*-like horse in a Blancan deposit as far as I am aware. However, there is no reason why this type of horse should not have lived in North America prior to the Irvingtonian. Similar *E. scotti*-like teeth may also be present in other Blancan faunas from the southwest (C. W. Hibbard, personal communication, 1969). It is interesting

that in the nearby Hudspeth local fauna (Strain, 1966) which correlates very closely with the Red Light local fauna, there is a horse of similar size but represented only by a pair of lower jaws. The cheek teeth of this specimen are generally plesippine in character but somewhat atypical and perhaps advanced, especially in that the external re-entrant valley in both M_1 s and the right M_2 does not pass between the flexids. Strain assigned this specimen to *E. (Plesippus) idahoensis*.

There are two possible explanations for this situation. These two faunas of equivalent age and separated only by a minor mountain range may have had a different species of large horse in each, or both may have had a single species of large horse in which the upper cheek teeth were similar to *E. scotti* and the lowers similar to *E. (P.) idahoensis*. I favor the latter explanation. Only the discovery of associated upper and lower dentitions will clarify this point. Along this line, it should be mentioned that in some of the lower dentitions of *E. scotti* from the Gilliland local fauna, the external re-entrant valley does penetrate between the flexids in a few molars and the metaconid-metastylid valley is more V-shaped than in more typical *E. scotti* material, thus showing some plesippine characteristics. The lower premolar, TMM 40856-39, is only partially preserved but resembles the premolars of the Hudspeth specimen.

Probable habitat.—All of the large Pleistocene horses were grazers living in more or less open country.

Equus (Plesippus) cf. simplicidens (Cope), 1893

Figure 16, C, D

Material.—Partial right mandible with DP_{2-4} and alveoli for incisors, TMM 40856-46; partial right mandible with DP_{2-4} and alveolus for P_1 , TMM 40664-24; two left DP_3 s?, TMM 40664-190 and 40856-40; left radius-ulna, TMM 40664-268; right calcaneum, TMM 40664-248; two partial calcanea, TMM 40664-55 and -208; five first phalanges, TMM 40664-39, -41, and -42, 40856-2, and 40855-8; two second phalanges, TMM 40855-6 and -35; five ungual phalanges, TMM 40855-10, 40856-15, 40664-30, -31, and -34.

Description.—The identification of the medium sized horse in this fauna is primarily based on a lower cheek tooth found in an abandoned sheepherder's cabin in the outcrop area of the Love Formation. This tooth can be definitely assigned to *Equus (Plesippus) simplicidens*, but since its original locality is unknown, it is not catalogued, figured, or described. The deciduous material described below is considerably smaller than material from the Gilliland local fauna assigned to *E. scotti* by Hibbard and Dalquest (1966). It is too large to belong to *E. (asinus) cumminsi* and is similar in size and morphology to deciduous teeth from faunas con-

taining *E. (P.) simplicidens* in southwestern Kansas.

The partial right mandible, TMM 40856-46, has the alveoli for the incisors so damaged that it is difficult to identify the individual alveoli. The mandibular foramen is present but the area where the P_1 would be is missing. All of the mandible posterior to about the middle of the alveolus for an erupting M_1 is missing. The teeth are only slightly worn. Since wear is so slight, a description of the enamel pattern would be of little use and the reader is referred to the figure of the specimen (fig. 16, C). Measurements of this dentition and other deciduous teeth are given in table 15.

The other mandible with a deciduous dentition, TMM 40664-24, is broken at the base of the alveoli for the incisors and only fragments of the mandible are preserved posterior to the DP_2 . The mandibular foramen and a small, shallow alveolus for the P_1 are preserved. The teeth are unworn, only the cement covering the highest cusps showing any wear.

The two left DP_3 s? are moderately worn. The parastylid is broken off of TMM 40664-190. Both teeth are laterally compressed, very narrow in comparison to length. The metastylid and metaconid are long and narrow with a wide, V-shaped groove between them. The pli caballinid is well developed. The parastylid and hypostylid are very poorly developed but the configuration of the lingual side of the teeth indicates that both may develop with greater wear. These specimens are quite similar to deciduous material referred to *E. (Asinus) pons* by Quinn (1958). However, the validity of this taxon is questionable.

The following skeletal material is referred on the basis of relative size.

The left radius-ulna is damaged but most measurements can be made or estimated fairly accurately. Table 16 gives the measurements for it compared with several other species of *Equus*.

The length of the complete calcaneum is 122 mm. Gazin (1936) lists lengths of 104 to 119 mm for five calcanea of *Equus (Plesippus) shoshonensis* and 114 and 120 mm for two calcanea of *E. (P.) simplicidens*. The two partial calcanea are similar in size to the complete one.

Measurements of the five first phalanges are given in table 14; of the two second phalanges, in table 13; of the five ungual phalanges, in table 17.

Probable habitat.—This form is another open country grazer.

Equus (Asinus) cumminsi (Cope), 1893

Figure 16, E, F, G

Material.—Right P_2 , TMM 40856-104; right lower molariform tooth, TMM 40964-1; left lower molariform tooth, TMM 40664-2; left upper molariform tooth, TMM 40664-227; left calcaneum, TMM 40856-9; two left astragali, TMM 40856-7 and 40891-13; three first phalanges, TMM 40856-3

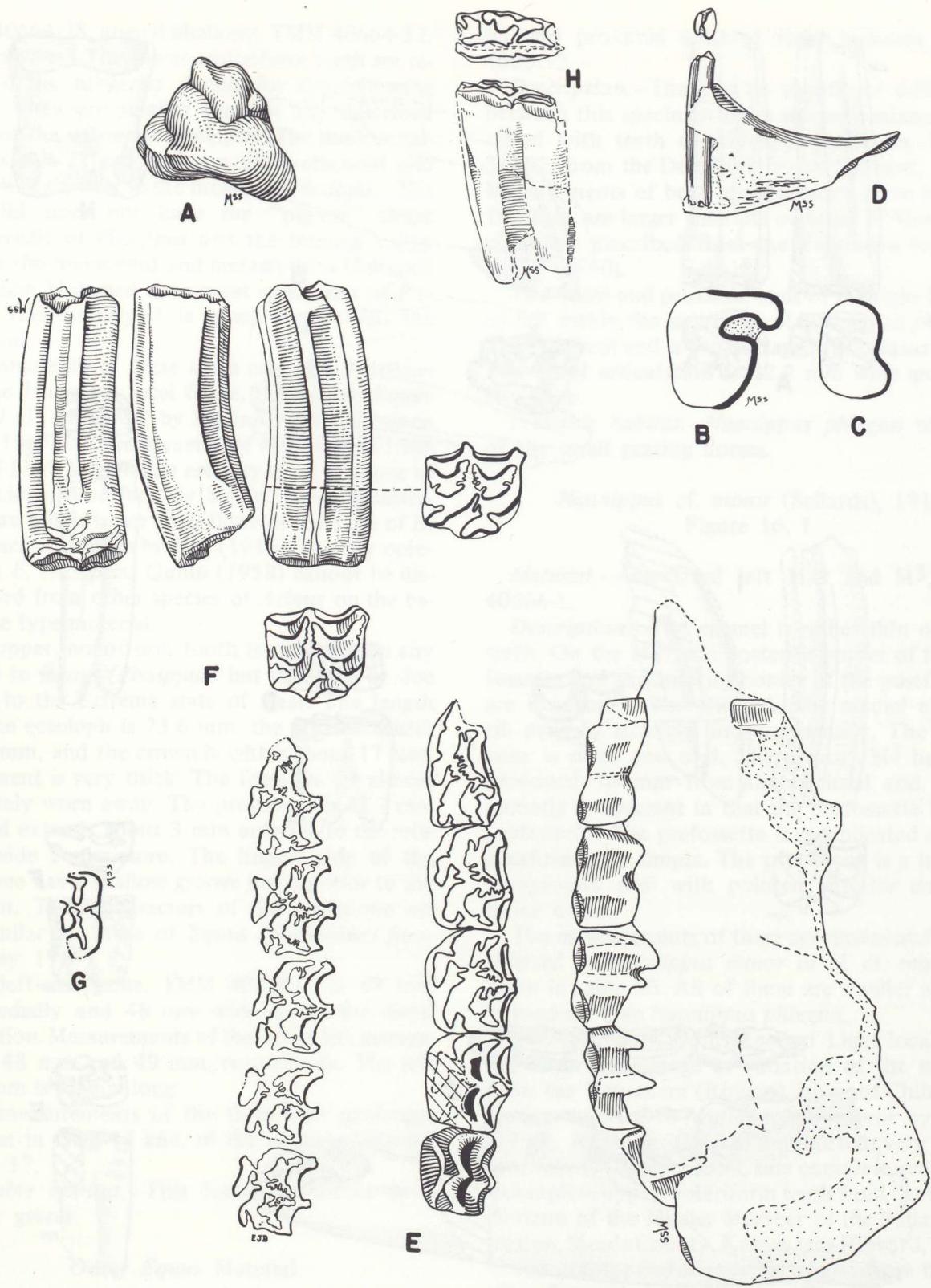


Fig. 15.—A. Mastodont, gen. et sp. indet.; cone from cheek tooth, TMM 40664-26, occlusal view (X1).
 B. Leporidae, type A gen. et sp. indet.; cross-section of upper incisor, TMM 40857-72 (X10).
 C. Leporidae, type B gen. et sp. indet.; cross-section of upper incisor, TMM 40857-73 (X10).
 D. Leporidae, gen. et sp. indet.; partial right mandible with P_4 , TMM 40856-45, occlusal and external views (X2).
 E. *Equus* aff. *scotti*; partial left maxillary with DP_2 - 4 , M_1 , and M_2 , TMM 40664-23, external and occlusal views, occlusal view of adult teeth after sectioning (X½).
 F. *Equus* aff. *scotti*; right $P_3?$, TMM 40664-20, external, anterior, internal, occlusal, and sectioned views (X½).
 G. *Equus* aff. *scotti*; right P_3 or P_4 , TMM 40856-39, occlusal view (X½).
 H. *Equus* sp., aberrant P_2 , TMM 40664-22, occlusal and external views (X½).



Fig. 16.—A. *Equus aff. scotti*, associated partial right M¹ and M², TMM 40664-255, occlusal and internal views (X½).
 B. *Equus aff. scotti*, left M³ in maxillary fragment, TMM 40664-21, external and occlusal views (X½).
 C. *Equus (Plesippus) cf. simplicidens*, right mandible with DP₂₋₄, TMM 40664-24, occlusal and external views (X½).
 D. *Equus (Plesippus) cf. simplicidens*, left DP_{3?}, TMM 40856-40, occlusal and external views (X½).
 E. *Equus (Asinus) cumminsi*, right lower molariform tooth, TMM 40964-1, occlusal and external views (X½).
 F. *Equus (Asinus) cumminsi*, right P₂, TMM 40856-104, occlusal and external views (X½).
 G. *Equus (Asinus) cumminsi*, left lower molariform tooth, TMM 40664-2, occlusal and external views (X½).
 H. *Nannippus phlegon*, second phalange, TMM 40855-22, anterior view (X1).
 I. *Nannippus cf. minor*, associated left M^{2?} and M³, TMM 40866-1, external and occlusal views (X1).

and -8, 40664-38; ungual phalange, TMM 40664-32.

Description.—The lower molariform teeth are referred to the subgenus *Asinus* for the following reasons. They are smaller than in any described species of the subgenus *Plesippus*. The median valley does not extend between the metaconid and metastylid as it does in the molars of *Plesippus*. The metastylid does not have the "pig-ear" shape characteristic of *Plesippus* and the internal valley between the metaconid and metastylid is U-shaped rather than V-shaped as in most specimens of *Plesippus*. The metastylid is much larger than the metaconid.

Measurements of these teeth and of a dentition from the Hudspeth local fauna, referred to *Equus (Asinus) cf. cumminsi* by Strain (1966), are given in table 18. The measurements of the material from the Red Light local fauna are very close to those of the specimen described by Strain. These measurements are much larger than those of the type of *E. (A.) francisci* as given by Hay (1915). It is my opinion that *E. (A.) pons* Quinn (1958) cannot be distinguished from other species of *Asinus* on the basis of the type material.

The upper molariform tooth is smaller than any referred to *Equus (Plesippus)* but this may be due in part to the extreme state of wear. The length along the ectoloph is 23.6 mm, the greatest width is 25.7 mm, and the crown height is about 17 mm. The cement is very thick. The fossettes are almost completely worn away. The protocone is 11.7 mm long and extends about 3 mm anterior to the relatively wide commissure. The lingual side of the protocone has a shallow groove just anterior to the midpoint. These characters of the protocone are very similar to those of *Equus (Hemionus) francisci* (Hay, 1915).

The left astragalus, TMM 40856-7, is 49 mm long medially and 48 mm wide across the distal articulation. Measurements of the other left astragalus are 48 mm and 49 mm, respectively. The left calcaneum is 96 mm long.

The measurements of the three first phalanges are given in table 14 and, of the ungual phalange, in table 17.

Probable habitat.—This form is another open country grazer.

Other *Equus* Material

Numerous vertebrae, partial teeth, and partial limb material could not be reliably assigned to any of the species of *Equus* described in this paper. One tooth, an aberrant P_2 , is figured as a matter of interest (fig. 15, H).

Nannippus phlegon (Hay), 1899

Figure 16, H

Material.—Second phalange, TMM 40855-22; dis-

tal and proximal ends of right humerus, TMM 40857-2.

Description.—There is no significant difference between this specimen and a second phalange associated with teeth of *Nannippus phlegon*, UMMP 33352, from the Deer Park fauna (Hibbard, 1956). Measurements of both specimens are given in table 19. Both are larger than the material of *Nannippus cf. minor* described from the Yepomera fauna by Lance (1950).

The distal and proximal ends of the right humerus fall within the size range of *Nannippus phleton*. The proximal end is too damaged for measurement. The distal articulation is 42.2 mm wide and 20.9 mm deep.

Probable habitat.—*Nannippus phlegon* was one of the small grazing horses.

Nannippus cf. minor (Sellards), 1916

Figure 16, I

Material.—Associated left $M^2?$ and M^3 , TMM 40866-1.

Description.—The enamel is rather thin on both teeth. On the $M^2?$, the posterior border of the prefossette and the anterior border of the postfossette are moderately complicated. The medial external rib projects strongly anteroexternally. The protocone is small and oval. The unworn M^3 has been sectioned 16 mm from the occlusal end. It apparently is aberrant in that the prefossette is open posteriorly. The prefossette is complicated and the postfossette is simple. The protocone is a laterally compressed oval with pointed anterior and posterior ends.

The measurements of these specimens and others referred to *Nannippus minor* or *N. cf. minor* are given in table 20. All of them are smaller and less hypsodont than *Nannippus phlegon*.

The specimens from the Red Light local fauna fall within the range of variation of the material from the Yepomera (Rincon) fauna of Chihuahua, Mexico referred to *Nannippus cf. minor* by Lance (1950). Another (hitherto unreported) very similar specimen is UMMP 31350, one complete and several incomplete upper molariform teeth from the Caliche Horizon of the Missler Member of the Ballard Formation, Meade County, Kansas (see Hibbard, 1956).

The holotype of *Nannippus minor*, from the Alachua Formation of Florida, is an apparently deciduous upper premolar and a permanent upper molariform tooth (Sellards, 1916). The permanent tooth is slightly narrower, has a slightly smaller protocone, and has more complicated fossettes than the other small *Nannippus* teeth discussed. No other material of *N. minor* has been described from the Alachua Formation. The type material is not sufficient to definitely determine whether or not it is similar enough to the other small species of *Nannippus* discussed above so that they may be

TABLE 12

MEASUREMENTS IN MM OF METACARPALS III
OF VARIOUS SPECIES OF *EQUUS*

	TOTAL LENGTH	WIDTH OF PROXIMAL ARTICULATION	DEPTH OF PROXIMAL ARTICULATION	WIDTH OF DISTAL ARTICULATION	DEPTH ACROSS KEEL OF DISTAL ARTICULATION
TMM 40664-292 <i>E. aff. Scotti</i> Red Light l.f.	282	54.6	38	48.2	49
TMM 40856-51 <i>E. aff. scotti</i> Red Light l.f.	270	—	—	47.6	43.2
TMM 40891-2 <i>E. aff. scotti</i> Red Light l.f.	—	59.9	36.0	—	—
<i>E. (P.) shoshonensis</i> from Gazin (1936) 6 specimens Hagerman fauna	240-254	46.5-53	30-33.5	43.3-47.8	32.3-36.9
<i>E. (P.) simplicidens</i> from Gazin (1936) Blanco fauna	252	51.2	34	46	34
UMMP V39375 <i>E. scotti</i> Gilliland l.f.	233	54.5	35.7	53.4	38.8
UMMP V39376 <i>E. scotti</i> Gilliland l.f.	255	52.8	33.5	49.4	41.4

considered as conspecific.

Plaster casts of several additional specimens of *N. minor* from Florida were supplied by Dr. D. S. Webb of the Florida State Museum. They compare fairly well in size and pattern to the teeth from the Red Light local fauna.

Discussion.—These specimens represent a lineage of small nannippines from the Hemphillian to the Aftonian. The type is apparently from the Hemphillian (D. S. Webb, oral communication, 1966) as is the material from the Yeromera fauna (Lance, 1950). The material from the Red Light local fauna is assigned to the Nebraskan (this paper) and the material from the Missler Member is assigned to the Aftonian (Hibbard, 1956).

Probable habitat.—This group of small nannippines appears to have primarily a southern distribution. A number of specimens are known from the Yeromera fauna and from the Alachua Formation (D. S. Webb, oral communication, 1966). They are very rare north of Mexico and Florida. The smallest species of *Pliohippus*, *P. hondurensis* Olson and McGrew and *P. castilli* (Cope), also have a southern distribution. Olson and McGrew (1941) believed that the small size of these species of *Pliohippus* was a result of living in the more forested subtropical environments which would be rather marginal en-

vironment for horses.

I believe that the southern distribution, relatively brachydont teeth with thin enamel, and size of the small *Nannippus* specimens are reflections of their adaptation to a browsing habitat in subtropical forested or brushy areas.

AGE AND CORRELATION

There are two methods of subdividing the Pleistocene other than isotopic or geomagnetic dating. The first is based on faunal assemblages and divides the Pleistocene into the Blancan, Irvingtonian, and Rancholabrean Provincial Ages (Savage, 1951; Hibbard, *et al.*, 1965). The Blancan also includes the latest Pliocene. The second method is to correlate with the several glacial and interglacial events of the Pleistocene. It should be emphasized that these two age scales are independent, although often correlatable. The former is based on faunal criteria; the latter, on climatological criteria.

The Blancan Provincial Age is defined on the basis of the association of *Nannippus* and *Plesippus* within a fauna (Hibbard, 1958). *Glyptotherium*, *Equus (Plesippus) simplicidens*, *E. (Asinus) cumminsii*, *Geomys (Nerterogeomys) paenebursarius*, *Sigmodon hirsutus*, *Platygonus bicalcaratus*,

TABLE 13
 MEASUREMENTS IN MM OF SECOND PHALANGES
 OF VARIOUS SPECIES OF *EQUUS*

	GREATEST LENGTH	WIDTH OF PROXIMAL END	DEPTH OF PROXIMAL END	WIDTH OF DISTAL END
TMM 40856-4				
<i>E. aff. scotti</i>				
Red Light l.f.	49.4	52.0	32.7	44.6
TMM 40856-108				
<i>E. aff. scotti</i>				
Red Light l.f.	52.2	51.0	33.3	48.2
TMM 40664-36				
<i>E. aff. scotti</i>				
Red Light l.f.	48.0	49.8	31.6	43.0
TMM 40855-35				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	45.7	41.2	28.7	37.4
TMM 40855-6				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	41.9	39.6	26.7	37.6
<i>E. (P.) shoshonensis</i>				
from Gazin (1936)				
6 ant. phalanges				
Hagerman fauna	43.6-49.9	47.51	30-32.1	41.5-46.3
<i>E. (P.) shoshonensis</i>				
from Gazin (1936)				
4 posterior phalanges				
Hagerman fauna	47.2-49.5	45.8-49.5	31-31.4	38.8-42.5
<i>E. (P.) simplicidens</i>				
from Gazin (1936)				
ant. phalange				
Blanco fauna	48	50.5	32.2	47.4
<i>E. (P.) simplicidens</i>				
from Gazin (1936)				
2 post. phalanges				
Blanco fauna	49-50.2	48-48.7	31.5-32	40-41
UMMP V46511				
<i>E. scotti</i>				
Gilliland l.f.	53.6	56.2	36.8	app. 46
UMMP V46514				
<i>E. scotti</i>				
Gilliland l.f.	50.4	53.7	34.1	48.0
UMMP V35669				
<i>E. scotti</i>				
Gilliland l.f.	55.1	55.5	36.1	53.0

and the undescribed long-limbed camel are seemingly restricted to the Blancan. Only *Equus* aff. *scotti* of the taxa described from the Red Light local fauna is unexpected in a Blancan fauna. Thus, the Red Light local fauna can be assigned to the Blancan Provincial Age.

The Blancan includes latest Pliocene and early Pleistocene through the early Kansan (Hibbard, et al., 1965). *Glyptotherium*, *Camelops*, and *Paramylodon* are unknown in the Pliocene portion of the Blancan (Hibbard, et al., 1965). *Sigmodon hudspethensis* is more advanced than *Sigmodon intermedius*

from the Rexroad local fauna which is assigned to the upper Pliocene part of the Blancan (Hibbard, 1954). Using these two criteria, I assign the Red Light local fauna to the Pleistocene portion of the Blancan, either Nebraskan or Aftonian.

If, as discussed in the section of stratigraphy, the Love Formation was formed during a pluvial stage, the age of the fauna is Nebraskan. None of the fauna is adapted to a cool climate but it is not necessary to postulate a cool climate during the Nebraskan this far south of the glacial advance (Hibbard, 1960). After studying molluscan faunas,

TABLE 14

MEASUREMENTS IN MM OF FIRST PHALANGES
OF VARIOUS SPECIES OF *EQUUS*

	GREATEST LENGTH	WIDTH OF PROX. END	DEPTH OF PROX. END	WIDTH OF DISTAL END
TMM 40664-37				
<i>E. aff. scotti</i>				
Red Light l.f.	87	56.8	37.1	43.9
TMM 40856-1				
<i>E. aff. scotti</i>				
Red Light l.f.	88	57.9	40.9	43.2
TMM 40891-1				
<i>E. aff. scotti</i>				
Red Light l.f.	90	app. 58	app. 42	—
TMM 40664-39				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	85	53.7	35.6	40.2
TMM 40664-41				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	80	app. 46	—	41.3
TMM 40664-42				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	82	45.6	33.2	42.1
TMM 40856-2				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	app. 78	app. 50	—	41.0
TMM 40855-8				
<i>E. (P.) cf. simplicidens</i>				
Red Light l.f.	78	48.0	37.2	39.0
TMM 40856-3				
<i>E. (A.) cumminsi</i>				
Red Light l.f.	75	44.2	app. 32	34.0
TMM 40856-8				
<i>E. (A.) cumminsi</i>				
Red Light l.f.	app. 72	app. 37	app. 27	app. 33
TMM 40664-38				
<i>E. (A.) cumminsi</i>				
Red Light l.f.	app. 79	41.5	app. 31	—
<i>E. (P.) shoshonensis</i>				
from Gazin (1936)				
6 anterior phalanges				
Hagerman fauna	82.5-87.3	46-51	34.2-38.5	39.5-43
<i>E. (P.) shoshonensis</i>				
from Gazin (1936)				
5 posterior phalanges				
Hagerman fauna	78.3-83	47-51.6	35.4-38.7	38-40.4
<i>E. (P.) simplicidens</i>				
from Gazin (1936)				
anterior phalange				
Blanco fauna	86	53.2	37	43.5
<i>E. (P.) simplicidens</i>				
from Gazin (1936)				
1 posterior phalanges				
Blanco fauna	78	52.4-52.8	37.2-38	40.7-42
UMMP V46523				
<i>E. scotti</i>				
Gilliland l.f.	93.0	65.6	44.0	45.8

(CONTINUED)

TABLE 14 (CONTINUED)

	GREATEST LENGTH	WIDTH OF PROX. END	DEPTH OF PROX. END	WIDTH OF DISTAL END
UMMP V46501 <i>E. scotti</i> Gilliland l.f.	89.7	61.6	40.5	49.6
UMMP V46518 <i>E. scotti</i> Gilliland l.f.	86.8	61.0	39.3	50.2
UMMP V46524 <i>E. scotti</i> Gilliland l.f.	91.2	60.2	38.4	57.2
UMMP V46500 <i>E. scotti</i> Gilliland l.f.	89.6	60.6	38.9	45.6

Taylor (1966) asserted that the effect of the Nebraskan was less than that of subsequent glaciations and suggested that the Nebraskan and Aftonian faunas of the Great Plains are actually older than the classic Nebraskan. Hibbard, *et al.*, (1965) remarked that the late Kansan Cudahy fauna is the oldest fauna that shows a major southward ecological shift of the mammals in the Great Plains area.

Correlation of the Red Light local fauna with other Blancan faunas except the Hudspeth local fauna is meaningless. Few of the taxa of larger mammals can be identified to species. Those which can be identified seem to range through much of the Blancan. The numerous publications of Hibbard on the fossil faunas of the Great Plains indicate that only the smaller mammals are useful in detailed correlations. The two taxa of rodents, identifiable to species, from the Red Light local fauna are not known from any other fauna except the Hudspeth local fauna.

Even when the faunas from the bolson area of the Southwest are better known, correlation with the well known Plio-Pleistocene sequence of the Great Plains will be difficult. The bolson area was probably relatively drier at all times and less affected by the Pleistocene glaciations. The mountains in this region probably provided different ecologic niches even if the climate resembled that of the Great Plains. Therefore, the makeup of the faunas, particularly the microvertebrates, would have been different in the two areas at any given time. It may become possible to tie these areas together when the Blancan faunas from the Texas Panhandle are more completely studied. The microvertebrates from these faunas are virtually unknown.

Correlation of the Red Light local fauna with the Hudspeth local fauna (Strain, 1966) from the Hueco Bolson, west of the Red Light Bolson, is very good. A similar stratigraphic succession occurs in both bolsons and the faunas are similar. A comparison of faunal lists (table 21) shows that of 17

taxa of vertebrates reported from the Hudspeth local fauna, only *Scalopus*, *Citellus mcgheeii*, *C. finlayensis*, *Equus (Plesippus) idahoensis*, *Tapirus cf. copei*, and *Gigantocamelus* (=*Titanotylopus*) are lacking in the Red Light local fauna. *Gigantocamelus* can probably be removed from this list because the metapodial fragments assigned to this genus by Strain may belong to the large *Camelops* from the Red Light local fauna or some of the material assigned to the large *Camelops* from the Red Light local fauna may actually belong to *Gigantocamelus*. *Equus (Plesippus) idahoensis* might also be removed from the list as explained in the systematic description of *Equus aff. scotti*. The absence of the other taxa from the Red Light local fauna may be ascribed to accidents of collection or preservation. Many taxa in the Red Light local fauna are absent in the Hudspeth local fauna, probably because more than ten times as many specimens are known from the Red Light localities. Both *Sigmodon* and *Geomys* evolved rapidly during the Pleistocene. Because these genera are represented by identical species in both faunas, I believe that the faunas are of equivalent age.

Correlation of these two faunas would indicate an age of Nebraskan for the Hudspeth local fauna rather than Aftonian as suggested by Strain (1966).

In summary, the Red Light local fauna is Blancan, probably Nebraskan, equivalent in age to the Hudspeth local fauna, and not faunally correlatable with other Blancan faunas.

PALEOECOLOGY

Most of the Bramblett Formation was deposited during extremely arid conditions. This conclusion is inferred from the type of deposition and the apparent lack of fossils in all but the uppermost part of the formation compared to their abundance higher in the section.

I interpret the Aguila local fauna, from the upper

TABLE 15

MEASUREMENTS IN MM OF DECIDUOUS TEETH
OF *EQUUS (PLESIPPUS) CF. SIMPLICIDENS*
FROM THE RED LIGHT LOCAL FAUNA

		GREATEST LENGTH INCLUDING CEMENT	GREATEST WIDTH INCLUDING CEMENT
TMM 40856-46	DP ₂₋₄	117	—
	DP ₂	40.4	15.1
	DP ₃	35.8	15.5
	DP ₄	38.7	15.4
TMM 40664-24*	DP ₂₋₄	106	—
	DP ₂	37.6	12.6
	DP ₃	32.9	12.3
	DP ₄	36.7	11.4
TMM 40856-40	DP _{3?}	33.6	15.8
TMM 40664-190	DP _{3?}	33.3	14.2

*The cement on this specimen is thinner than on the others.

TABLE 16

MEASUREMENTS IN MM OF THE RADIUS-ULNA
OF SEVERAL SPECIES OF *EQUUS*

	TOTAL LENGTH	LENGTH OF RADIUS ALONG INNER SIDE	WIDTH OF PROXIMAL END OF RADIUS
TMM 40664-268			
<i>E. (P.) cf. simplicidens</i>			
Red Light l.f.	est. 425	333	app. 76
<i>E. (P.) shoshonensis</i>			
5 specimens			
from Gazin (1936)			
Hagerman fauna	415-436	316-336	74.5-82
<i>E. (P.) simplicidens</i>			
from Gazin (1936)			
Blanco fauna	429	334	82

part of the Bramblett Formation, to be the first indication of a slightly more humid climate. The basis for this is the sudden appearance of plant, gastropod, and vertebrate remains in an otherwise barren section and near the base of the transition from playa to fluvial deposition. The environment was still relatively arid since the vertebrate fauna is impoverished. A very small chub, *Gila* sp., is the only taxon of fish identified. The only mammalian fossil collected was the humerus of a rodent. The gastropods, birds, and plants have not been identified.

As the rainfall gradually increased, the playa environment became one of intermittent streams with more diverse ecologic niches in the surrounding terrestrial environment. These conditions are reflected in the faunas and sediments of the stratigraphically lower, vertebrate localities within the Love Formation, TMM 40857, 40866, and 40963. The fill at these localities is mostly interbedded fluvial silt and sand with some reddish clay, which appears to be a floodplain deposit, and a few thin beds of gravel. The environment of deposition is fluvial.

TABLE 17

MEASUREMENTS IN MM OF UNGUAL PHALANGES
OF VARIOUS SPECIES OF *EQUUS*

	LENGTH ALONG MIDLINe	GREATEST WIDTH
TMM 40855-10 <i>E. (P.) cf. simplicidens</i> Red Light l.f.	48.3	53.2
TMM 40856-15 <i>E. (P.) cf. simplicidens</i> Red Light l.f.	app. 48	—
TMM 40664-30 <i>E. (P.) cf. simplicidens</i> Red Light l.f.	48.0	51.1
TMM 40664-31 <i>E. (P.) cf. simplicidens</i> Red Light l.f.	50.9	—
TMM 40664-34 <i>E. (P.) cf. simplicidens</i> Red Light l.f.	53.0	app. 59
TMM 40664-32 <i>E. (A.) cumminsi</i> Red Light l.f.	app. 42	app. 48
<i>E. (P.) shoshonensis</i> from Gazin (1936) 5 anterior phalanges Hagerman fauna	56.5-60	59.3-68.7
<i>E. (P.) shoshonensis</i> from Gazin (1936) 4 posterior phalanges Hagerman fauna	51.7-60	54-65
<i>E. (P.) simplicidens</i> from Gazin (1936) anterior phalange Blanco fauna	59.3	65
<i>E. (P.) simplicidens</i> from Gazin (1936) 2 posterior phalanges Blanco fauna	57-60.2	58.5-60.5

The fauna from these localities, a part of the Red Light local fauna, is more diverse than the Aguila local fauna but less diverse than the part of the Red Light local fauna from localities higher in the section. A small catfish and *Gila nigrescens* or *G. pandora* appear to have lived in an intermittent drainage. Only two unidentifiable turtle fragments are known from these localities, whereas aquatic turtles are common from the stratigraphically higher localities. Unidentified frog and snake material, unidentifiable gastropod fragments, and two specimens of *Phrynosoma* were also collected.

The rodent assemblage — *Sigmodon hudsonensis*, *Geomys (Nerterogeomys) paenebursarius*, *Prodipodomys* sp., *Perognathus* sp., and *Onychomys* sp. — strongly suggests a semiarid environment.

Recent *Geomys* prefer deep, sandy soils. The diversity of large mammals is rather low. *Nannippus phlegon*, *Nannippus* cf. *minor*, *Equus* sp., a mastodon, a large camel, and a small artiodactyl have been identified. The fauna and sediments suggest an environment similar to that which exists in the area today.

The sediments and fauna from localities stratigraphically higher in the Love Formation indicate a still greater increase of moisture and very diverse ecologic niches in the terrestrial environments. The localities in the upper part of the section are those above TMM 40857 (fig. 3).

The flathead catfish *Pylodictis olivaris* strongly prefers flowing water and is rarely found in pools along intermittent streams (Clark Hubbs, oral com-

TABLE 18

MEASUREMENTS IN MM OF LOWER TEETH
OF *EQUUS (ASINUS) CUMMINSI*

		LENGTH ACROSS ENAMEL	WIDTH ACROSS ENAMEL	CROWN HEIGHT
TMM 4085-104 <i>E. (A.) cumminsi</i> Red Light l.f.	P ₂	30.1	14.1	18
TMM 40964-1 <i>E. (A.) cumminsi</i> Red Light l.f.	?	26.2	app. 14	app. 45
TMM 40664-2 <i>E. (A.) cumminsi</i> Red Light l.f.	?	25.7	13.3	82
TMM 40246-1 <i>E. (A.) cf. cumminsi</i> from Strain (1966) Hudspeth l.f.	P ₂	31.8	15.0	—
	P ₃	28.0	15.5	—
	P ₄	27.0	14.8	—
	M ₁	25.4	13.8	81.0
	M ₂	25.0	12.5	79.0

munication, 1967). The largest individual of this species represented in the collection had a standard length of about 800 mm (John G. Lundberg, written communication, 1967). It is primarily piscivorous, indicating the presence of other uncollected species of fish. Two genera of aquatic turtles, *Trionyx* and *Pseudemys*, have been identified. These identifications support the presence of permanent water. *Trionyx* is most commonly found in still pools. This permanent drainage flowed along the axis of the bolson to the southeast and had periodic severe floods. The evidence for these statements is given in the section on stratigraphy. The axial stream, even if it headed in the region of Eagle Flat to the east, drained a rather small area. Moderate rainfall, at the minimum, would have been necessary to maintain a permanent, flowing stream. The evidence for periodic flooding suggests that the rainfall may have had a seasonal distribution.

The absence of such aquatic vertebrates as beaver and alligator seems anomalous. The absence of beaver may be ascribed to accident of collection or to the lack of suitable food along the drainage. Since alligators contribute much skeletal material upon death and disarticulation, their absence probably means they did not live there, but why they did not is not clear.

The lack of mollusks in the sediments is undoubtedly due to a lack of preservation, for the environments, both aquatic and terrestrial, were favorable to mollusks. Cementation of the sedi-

ments by calcite, formation of caliche, and etching of limestone pebbles show that there has been percolation of ground water with solution of calcium carbonate. This probably destroyed any molluscan material. The fact that the only large accumulation of gastropod material in the bolson fill is preserved in an impermeable clay supports this hypothesis.

The terrestrial turtles — *Terrapene*, *Gopherus*, and *Geochelone* — were mostly herbivorous. Their primary source of food would have been succulent vegetation and grass (Brattstrom, 1961; Auffenberg and Milstead, 1965). Naturally, they could not reach vegetation very high above the ground. Recent *Terrapene* can exist in areas of rather low temperatures by burrowing to escape the cold. The *Geochelone* is too large a form to burrow and would probably die of enteritis if subjected to frosty weather for several days (Hibbard, 1960). The *Gopherus* was probably too large to burrow, as do some of the smaller Recent species, and had similar temperature tolerances as did *Geochelone*. Brattstrom (1961) and Auffenberg and Milstead (1965) consider *Gopherus* and *Geochelone* to indicate tropical to subtropical environments.

Few microvertebrate remains have been collected from these deposits. Their lack is probably due to collection techniques. No large-scale screening or washing was attempted because no place looked as if it would yield enough material to justify my working it alone in the short time available. The only rodent identified is *Cratogeomys*. Other un-

identified rodents are represented by limb material. Much unidentifiable lagomorph limb material was also collected.

The most striking aspect of the mammalian fauna is the great diversity of large herbivores. A minimum of fifteen taxa has been identified from these stratigraphically higher localities, and the actual total may be greater. *Nannippus cf. minor*, known only from the lower localities, may have continued to live in the area, there may have been more than one mastodont, and the camel material suggests that more than the four identified taxa of camels lived thereabout. Two additional taxa of large herbivores, *Tapirus cf. copei* and a large cervid, are known from the Hudspeth local fauna (Strain, 1966 and oral communication, 1965). The natural diversity of herbivores in modern North America is not nearly as great as in this fauna. The only modern area which supports a similar diversity of large herbivores is in the savannah environments of modern East Africa (Bourlière, 1963).

The fifteen known taxa of large herbivores from these localities have been divided into two groups, those which were primarily grazers and those which were primarily browsers. The term "browser" is used for any animal whose main food was vegetable matter other than grass. A discussion of the probable habitat of each animal is given at the end of its description in the section on systematic paleontology.

Only four taxa, all horses, are considered to have been grazers. They are *Equus aff. scotti*, *E. (P.) cf. simplicidens*, *E. (Asinus) cumminsi*, and *Nannippus phlegon*. This diversity of closely related grazers would require large grassy areas with either a diversity of grasses or a grazing succession such as that described for the Rukwa Valley, Tanganyika, by Vesey-FitzGerald (1960). I believe that the diversity of equids in North American Pliocene and early Pleistocene faunas is analogous to the diversity of bovids in modern Africa. Both of these groups diversified to fill most of the niches available for large grazing mammals in their respective continents.

The long-limbed camels, *Tanupolama cf. blanconensis* and the undescribed form, appear to be convergent toward the African giraffes. These long-limbed browsers would require moderately tall brush and trees scattered in an open environment to allow these animals access to the food. The combination of horses and giraffoid camels indicates a savannah environment of grassy plains with scattered trees or high brush. This savannah would have extended from the axial drainage to the mountain front. *Paramylodon*, *Camelops*, and several other browsing forms probably inhabited the savannah, but the total diversity of browsers is too great to have lived only in a savannah environment. In addition to the four taxa of browsers already mentioned, *Megalonyx*, *Glyptotherium texanum*,

TABLE 19

MEASUREMENTS IN MM OF SECOND PHALANGES
OF *NANNIPPUS PHLEGON*

	TMM 40855-22 RED LIGHT L.F.	UMMP 33352 DEER PARK FAUNA
Length along midline	29.2	29.9
Greatest proximal width	25.0	24.7
Greatest distal width	23.4	21.3
Thickness, just proximal to the distal articulation	13.0	13.0

the mastodont, *Platygonus bicalcaratus*, *Tanupolama* sp., *Odocoileus?* sp., and *Capromeryx?* sp. are considered to have been browsers.

Two areas may have contained much browse: the banks of the drainage system and the mountainous regions surrounding the basin. The banks were probably covered with succulent vegetation or brush. The more clumsy, ponderous forms such as *Megalonyx*, *Glyptotherium texanum*, and the large terrestrial turtles would have difficulty traversing rugged terrain. They probably browsed along the drainage or in the savannah. In Africa, the smaller browsing artiodactyls are usually in mountainous or hilly brushlands. By analogy, *Odocoileus?* sp., *Capromeryx?* sp., and *Tanupolama* sp. probably inhabited the upland brushy area. The mastodont and *Platygonus bicalcaratus* could have utilized any or all of the environments.

Most carnivores are more labile in their ecologic tolerances than herbivores. Nevertheless, *Urocyon cf. progressus* and *Felis cf. rexroadensis* were almost certainly brushland forms. *Borophagus* sp. and *Ischyrosmilus* sp. may have been primarily savannah dwellers. *Canis cf. lepophagus* and *Taxidea* sp. might have lived anywhere or everywhere. When detailed information as to the environments, fauna, and ecology of the different African areas becomes available, it may be possible to make thorough comparisons between them and the environment of the Red Light local fauna. James G. Mead and Peter Parks tell me that environmental complexes near Nairobi, Kenya, resemble the complex postulated for the Red Light local fauna.

HISTORY OF THE RED LIGHT BOLSON

Much of the work on bolson history in this area has centered on the Hueco and Mesilla Bolsons and has concerned the history of an "ancestral Rio Grande." Most authors seem to have assumed the presence of a single major drainage in this area

TABLE 20

MEASUREMENTS IN MM OF UPPER MOLARIFORM TEETH
OF *NANNIPPUS MINOR* AND *N. CF. MINOR*

	CROWN HEIGHT	LENGTH ALONG ECTOLOPH	GREATEST WIDTH	LENGTH PROTOCONE	WIDTH PROTOCONE
TMM 40866-1, M ^{2?} Red Light l.f.	45	app. 15	14.1	6.0	3.0
TMM 40866-2, M ³ Red Light l.f.	50	14.8	10.9	5.7	2.0
UMMP 31350, complete upper molar Missler Member	39	13.8	15.1	5.7	3.0
UMMP 31350, incomplete upper molar Missler Member	27	14.5	—	5.7	—
FS 5867, type, measurements taken from figure in Sellards, 1916 Alachua Formation	—	13.5	12.6	4.0	2.1
CIT 3758, M ^{1?} , these and following measurements taken from Lance, 1950 Yepomera fauna	42	16.6	14.7	6.1	3.2
CIT 3760, P ^{4?} Yepomera fauna	25	13.4	14.3	5.3	3.3
CIT 3922, M ^{2?} Yepomera fauna	17	12.9	15.7	4.9	3.3
CIT 3923, P ^{3?} Yepomera fauna	24	13.5	14.4	5.2	3.4

throughout the Late Tertiary and Pleistocene. There is no definite evidence for such a drainage in the late Pliocene and early Pleistocene deposits. I believe that the term "ancestral Rio Grande" should not be used for pre-Kansan drainages because it has a genetic connotation and may bias thinking when applied to these drainages. The pre-Kansan drainage pattern was probably quite unlike that of the present Rio Grande. No attempt will be made to synthesize the literature on the Mesilla and Hueco Bolsons. The reader is referred to Strain (1966) and Ruhe (1962) for a synthesis.

To reconstruct the history of the Red Light Bolson one must consider its relationships with the chain of bolsons to the east and southeast and the Hueco Bolson to the northwest. Even when all are considered, many parts of their history are admittedly hypothetical. The two main reasons for this are the lack of any datable fossils from the deposits of the bolsons to the east and southeast and the lack of detailed information about bolson deposits in the adjoining areas of Mexico.

The age of the faulting that created the basin and range structure in this area can only be determined as post-Oligocene and pre-Nebraskan from evidence

in this area. According to Stevens *et al.* (1969), the major basin and range faulting in Big Bend National Park, to the east, cuts sediments of early Ari-kareean age (earliest Miocene). Although there is no proof, it seems unlikely that the major faulting in the area of the Red Light Bolson is any younger than early Pliocene.

The age and type of basal deposits in the Hueco and Red Light Bolsons are not known. The Tarantula Gravel described by DeFord and Bridges (1959) is probably the basal deposit of the Green River Bolson. This unit is the remains of a bahada gravel shed from the Rim Rock Fault. With the exception of the Tarantula Gravel, little evidence remains of the early part of basin filling.

The lower part of the Bramblett Formation in the Red Light Bolson, the lower part of the Fort Hancock Formation in the Hueco Bolson (Strain, 1966), the bolson fill studied by Dickerson (1966) in the northern part of the Presidio Bolson, and possibly the bolson fill studied by Dietrich (1966) farther south in the Presidio Bolson seem to have been deposited during the same climatic interval. This interval is believed to be arid as shown by the type of deposits and accompanying lack of fos-

TABLE 21
COMPARISON OF THE RED LIGHT AND HUDPETH LOCAL FAUNAS

<i>RED LIGHT LOCAL FAUNA</i>	<i>HUDPETH LOCAL FAUNA</i> (Strain, 1966)
Class OSTEICHTHYS <i>Gila nigrescens</i> or <i>pandora</i> <i>Pylodictis olivaris</i> Small catfish	
Class AMPHIBIA Unidentified anurans	
Class REPTILIA <i>Trionyx</i> sp. <i>Pseudemys</i> sp. <i>Geochelone</i> sp. <i>Gopherus</i> sp. <i>Phrynosoma</i> sp. Unidentified lizards and snakes	Testudinidae, gen. sp. undet. <i>Gopherus huecoensis</i>
Class AVES Odontophorinae, gen. undet. Passeriformes, indet. Accipitridae, indet. <i>Ciconia</i> sp.	
Class MAMMALIA <i>Megalonyx</i> sp. <i>Paramylodon</i> sp. <i>Glyptotherium texanum</i> <i>Geomys (Nerterogeomys) paenebursarius</i> <i>Cratogeomys</i> sp. <i>Prodipodomys</i> sp. <i>Perognathus</i> sp. <i>Onychomys</i> sp. <i>Sigmodon hudspethensis</i>	<i>Scalopus</i> sp. <i>Megalonyx</i> sp. <i>Glyptotherium</i> sp. <i>Geomys paenebursarius</i> <i>Sigmodon hudspethensis</i> <i>Citellus mcgheei</i> <i>Citellus finlayensis</i>
<i>Urocyon</i> cf. <i>progressus</i> <i>Canis</i> cf. <i>leopodus</i> <i>Borophagus</i> sp. <i>Ischyrosmilus</i> sp. <i>Felis</i> cf. <i>rexroadensis</i> <i>Taxidea</i> sp. Mastodont, indet. Leporidae, two types indet. <i>Platygonus bicalcaratus</i> <i>Tanupolama</i> sp. <i>Tanupolama</i> cf. <i>blancoensis</i> Undescribed long-limbed camel <i>Camelops</i> sp.	Leporidae, gen. sp. undet. <i>Tanupolama</i> sp.
<i>Odocoileus?</i> sp. <i>Capromeryx?</i> sp. <i>Equus</i> aff. <i>scotti</i>	<i>Gigantocamelus</i> sp. <i>Odocoileus</i> sp.
<i>Equus (Plesippus)</i> cf. <i>simplicidens</i> <i>Equus (Asinus)</i> <i>cumminsii</i> <i>Nannippus phlegon</i> <i>Nannippus</i> cf. <i>minor</i>	<i>Equus (P.) idahoensis</i> <i>Equus (P.) simplicidens</i> <i>Asinus</i> cf. <i>cumminsii</i> <i>Nannippus phlegon</i> <i>Tapirus</i> cf. <i>copei</i>

sils. The age of this arid interval is probably late Pliocene and perhaps older.

As rainfall increased with the beginning of the Nebraskan pluvial, the bolsons retained their internal drainage but filled more rapidly and coarser material, silt, and fine sand was deposited along

the axes of the bolsons. This is reflected in the increase of silt and fine sand in the upper part of Fort Hancock Formation and in the transition between the Bramblett and Love Formations. The Aguilas local fauna comes from strata representing the start of this moist period. This part of the

geologic record and that part of the geologic record equivalent to the Love and Camp Rice Formations seem to be missing from the studied areas of the Presidio Bolson.

As rainfall increased still more and filling of the bolsons progressed, an intermittent axial stream developed along the axis of each. These streams later became permanently flowing and deposited the Camp Rice Formation in the Hueco Bolson and the Love Formation in the Red Light Bolson.

The next part of the bolson history is purely speculative. The axial streams may have followed the trend of the basins into Mexico and gradually coalesced as the topography permitted or ended in large lakes. It seems improbable that the present Rio Grande drainage pattern, cutting across several mountain ranges in the area, developed at this time. The modern drainage probably developed later in the Pleistocene as a result of stream piracy. Richardson (1909) and Strain (1966) furnish evidence that the present drainage connection between the Mesilla and Hueco Bolsons was not established prior to the Kansan.

SUMMARY AND CONCLUSIONS

The sediments and faunas of the Red Light Bolson reflect a gradual change from arid-climate playa conditions to moist-climate fluvial conditions. Conditions during deposition of all but the upper part of the Bramblett Formation were arid and deposi-

tion was in a closed basin. Rainfall gradually increased and the playa deposits graded into the fluvial deposits of the Love Formation. The increase of rainfall is believed to have resulted from the onset of pluvial conditions. The impoverished Aguila local fauna lived during the beginning of the precipitation increase. The older part of the Red Light local fauna lived a little later when conditions appear to have been similar to those of the area today. An intermittent axial drainage existed during this time.

The younger part of the Red Light local fauna is diverse. The axial drainage was now permanently flowing and flooded occasionally, perhaps seasonally. Three major terrestrial environments are postulated from faunal evidence. Brush and succulent vegetation grew along the drainage, a savannah with scattered trees existed between the drainage and the mountain front, and the mountainous regions were mostly brush-covered.

The Bramblett and Love Formations are correlative with the Fort Hancock and Camp Rice Formations, respectively, in the Hueco Bolson.

The Aguila local fauna cannot be dated except that it is older than the Red Light local fauna. The Red Light local fauna lived during the Pleistocene portion of the Blancan, either Nebraskan or Aftonian. If the moist climate in which the Red Light local fauna lived resulted from glacial or pluvial conditions, the age of the fauna is Nebraskan. The Red Light local fauna can be correlated closely with the Hudspeth local fauna from the Hueco Bolson.

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